REPORT RESUMES

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TELEFACSIMILE IN LIBRARIES -- A REPORT OF AN EXPERIMENT IN FACSIMILE TRANSMISSION AND AN ANALYSIS OF IMPLICATIONS FOR INTERLIBRARY LOAN SYSTEMS.

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A MONTH LONG EXPERIMENT USING TELEFACSIMILE EQUIPMENT OFFERED AN OPPORTUNITY TO DEVELOP A SET OF PROCEDURES FOR THE USE OF EQUIPMENT IN LIBRARIES AND TO ANALYZE SYSTEM PERFORMANCE, THE NATURE OF THE DEMAND FOR THE SYSTEM, AND THE SYSTEM COST. FINDING GENERAL PRINCIPLES FOR THE DESIGN OF SUCH SYSTEMS FOR COOPERATING LIBRARIES, COMPARING TELEFACSIMILE WITH OTHER DELIVERY METHODS, AND MAKING RECOMMENDATIONS ABOUT THE DIRECTION OF FUTURE RESEARCH IN THE AREA WERE ALSO PART OF THE STUDY. A ONE WAY LINK FROM THE BERKELEY CAMPUS OF THE UNIVERSITY OF CALIFORNIA TO THE DAVIS CAMPUS WAS ESTABLISHED USING XEROX LONG DISTANCE XEROGRAPHY (LDX) EQUIPMENT. COPIES OF JOURNAL ARTICLES REQUESTED BY FACULTY MEMBERS ON THE DAVIS CAMPUS AND SELECTED SAMPLES OF A VARIETY OF MATERIALS USED TO TEST COPY QUALITY AND RESOLUTION WERE TRANSMITTED. FROM INFORMATION GATHERED ON AN ITEM CONTROL SHEET DURING THE ACTUAL OPERATION ON THE SYSTEM AND FROM A QUESTIONNAIRE DISTRIBUTED TO USERS OF THE SYSTEM, IT WAS POSSIBLE TO DETERMINE BOTH THE DEMAND FOR THIS SERVICE AND ITS COST. THE TIME INTERVAL FROM THE TIME OF RECEIPT OF A REQUEST BY THE STAFF ON THE BERKELEY CAMPUS TO THE NOTIFICATION OF THE REQUESTER THAT THE MATERIAL WAS READY AVERAGED NINE AND ONE-HALF HOURS. OF THIS, 2.3 HOURS WAS NEEDED FOR PAGING AND PROCESSING THE ITEM, 4.5 HOURS FOR TRANSMITTING IT, AND 2.7 HOURS FOR NOTIFICATION OF THE PATRON. FIXED MONTHLY COSTS OF THE ENTIRE SYSTEM WERE ABOUT 4000 DOLLARS. AVERAGE COST PER REQUEST WAS 12 DOLLARS. CONSIDERING THESE FACTORS, MOST MANUAL SYSTEMS SHOULD BE MADE TO OPERATE SMOOTHLY USING AVAILABLE SURFACE TRANSPORTATION BEFORE THE INVESTMENT IN TELEFACSIMILE IS MADE. APPENDICES--(1) LDX PROCEDURES MANUAL, A MANUAL FOR THE OPERATION OF THE SYSTEM, (2) MISCELLANEOUS INFORMATION, INCLUDING EQUIPMENT SPECIFICATIONS, AND (3) SAMPLES OF LDX COPIES AND ORIGINAL MATERIALS. THIS STUDY WAS CONDUCTED UNDER A GRANT FROM THE COUNCIL ON LIBRARY RESOURCES. (CM)

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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The Institute's involvement in research for improving interlibrary operations was initiated under the leadership of Raynard C. Swank, Dean of the School of Library Science, Berkeley, who acted as Principal Investigator. The study itself was suggested by David Heron, Librarian, University of Nevada, Reno, who graciously released Harold G. Morehouse from his normal duties so that in the planning phase of the study he could give us the benefit of his previous telefacsimile experience.

The Library of the University of California, Davis, participated in both this and an earlier study conducted by the University of Nevada. Richard Blanchard, University Librarian, Davis, was advisor to the study and supplied staff to help carry it out. In particular we wish to thank Gerald D. Newton, who served as Technical Coordinator at Davis, for his many excellent contributions to the study, and also Vera Loomis and the Interlibrary Loan people at Davis.

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W.D.S.
R.M.S.

I. INTRODUCTION

A. BACKGROUND

The use of telefacsimile systems to provide rapid transfer of information has great appeal. Because of a growing interest in the possible applicability of this technology to libraries, the Council on Library Resources provided a grant to the Institute of Library Research to conduct an experiment using telefacsimile equipment in a working library situation. The study was designed to explore the feasibility of telefacsimile for present interlibrary use. It provides information on the performance, cost, and utility of telefacsimile systems for libraries.

Speed is the essential characteristic which makes this equipment potentially valuable for library use and distinguishes it from current methods of remote access, which tend to be slow. For example, under current manual procedures, the service time for an interlibrary loan transaction between any two University of California campuses averages from six to seven working days. By reorganizing the manual procedures leading to delivery via surface transport, it would be possible to reduce average service time to one or two days. By contrast, the use of telefacsimile to replace surface transport has the potential of providing an average service time of less than four hours. Such rapid interlibrary service is unprecedented and would facilitate new modes of cooperative sharing and distribution of library resources.

Telefacsimile equipment alone, however, is not sufficient to provide this service. The equipment must be incorporated into a system whose manual procedures are efficient enough to take advantage of the rapid transmission speeds which the electronic equipment makes possible. Thus, the focus of this study was upon the total operating system used to provide fast, efficient service.

B. PURPOSE OF THE STUDY

The study had a three-fold purpose:

1. The development of a viable set of procedures for use of telefacsimile equipment in a library environment--specifically, the design of a system providing for the rapid transmission of requested journal articles.

2. The analysis of three specific elements and the relationship between them: a) performance of the system (in terms of the average time required to service a request), b) the nature of current and future demand for the system, and c) the cost of the system.

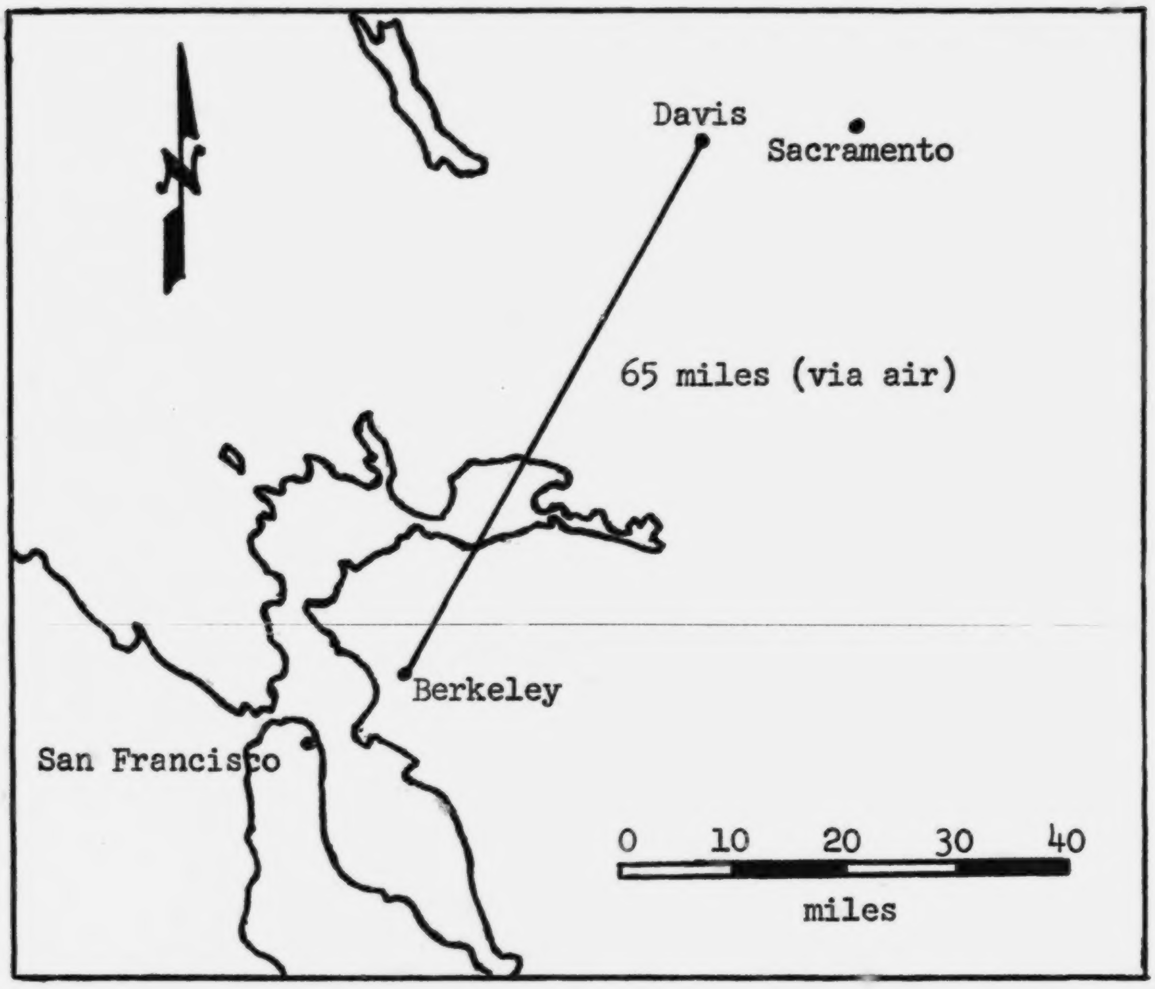
3. The extraction of general principles for: a) the design of systems for cooperating libraries, b) comparison of telefacsimile with other delivery systems, and c) recommendations on the direction future research should take in the area.

C. OPERATION OF THE EXPERIMENT

The experiment was conducted for a period of one month between the Berkeley and Davis campuses of the University of California. Figure 1 shows the approximate location of the two points with respect to the San Francisco region. Transmission was in one direction only; the transmitting station was located in the Library at Berkeley, and the receiving station in the Davis Library. The major portion of the transmission consisted of copies of journal articles (from volumes in the Berkeley Library) which were requested by faculty members on the Davis campus. The remainder of the transmission consisted of selected samples of a variety of materials to test copy quality and resolution.

FIGURE 1:

MAP OF THE SAN FRANCISCO BAY REGION



D. DESCRIPTION OF THE EQUIPMENT USED

The telefacsimile equipment used during the test was developed and manufactured by Xerox Corporation and is marketed under the name LDX (Long Distance Xerography). In relation to other telefacsimile devices, LDX is high speed, but costly. It consists of three basic elements: the Scanner (transmitter), the Transmission Link, and the Printer (receiver). In size, the Scanner and Printer are roughly comparable to the Xerox 914 Copier. (For a detailed description, see Appendix II, Section D.

The Scanner operates by sweeping a narrow light beam back and forth across the page to be copied. The reflection of this beam is focused into an electronic system where the variations in light reflected by the image on the page are converted into electrical impulses. These impulses are transmitted via either cable or microwave signals to the Printer, where they are converted back into light by a cathode ray tube. This tube projects the light impulses onto a drum, which produces a finished copy by the Xerox process. The copies are produced by the Printer on a continuous strip of paper which is automatically cut to size.

The Scanner is not capable of copying directly from bound or unbound volumes; it can accommodate sheet material only, ranging in size from a minimum of 3-1/4 inches by 5 inches to a maximum of 9-1/2 inches wide by any length. Original copies, Xerox copies or photocopies of printed pages, typescript, manuscript, line drawings, maps, etc. of any color may be transmitted, although the Printer is not able to reproduce half-tones. Copies are positive (black on white) and are, in general, less legible than copies produced by the Xerox 914.

If the Scanner is not equipped with an automatic document feeder, the pages of the material to be transmitted must be fed in manually one at a time. If this device is present, however, the pages of an entire document can be placed into the hopper and the sheets will be fed automatically into the Scanner.

The LDX requires a transmission link with a frequency band-width of at least 48 KC (kilocycles per second) which is equivalent to the capacity of twelve ordinary telephone lines. If faster performance is desired, a 240 KC link may be substituted, increasing output speed by a factor of 5 while approximately doubling transmission link costs. Channels of either capacity may be leased from a common carrier or may be set up as privately-owned microwave or co-axial cable systems. The 240 KC telephone company channel is commonly referred to as a TELPAK "C"; the 48 KC channel is referred to as TELPAK "A" or, more recently, Series 8000 service.

Scanner resolution is normally pre-set at the factory to either 135 or 190 lines per inch (LPI). The rate at which pages can be transmitted depends upon the resolution and the channel band-width employed, and ranges from .88 pages per minute to 8.75 pages per minute. Figure 2 indicates the various band-width/resolution/page rate relationships.

FIGURE 2: LDX PAGE RATE AS A
FUNCTION OF BAND-WIDTH AND RESOLUTION

Band-width Kilocycles per Second	Resolution Lines per Inch	Rate (8-1/2" x 11" Pages)		
		Pages per Minute	Minutes per Page*	Seconds per Page**
48 KC	135	1.75	0.57	34.3
	190	0.88	1.14	68.2
240 KC	135	8.75	0.11	6.9
	190	4.38	0.23	13.7

Source: extracted from LDX advertising brochure, Xerox Corporation, 610P356 REV.A, Xerox Corporation, Rochester, New York 14603.

* rounded to the nearest hundredth
** rounded to the nearest tenth

II. SUMMARY OF RESULTS AND CONCLUSIONS

The purpose of this section is to present an abstract of the results of the study. More detailed information on procedures and results will be found in Sections III and IV. In a telefacsimile system there are three principal features with which we are concerned--service time, demand characteristics and cost. Service time refers to the amount of time required to provide a requestor with the material that he desires. In designing the experiment we anticipated that between two and four hours would elapse between the time the requestor placed his request until the material was available on the Davis campus for pick-up. During the experiment this interval actually averaged nine and one-half hours.

Three major processing stages are distinguishable in the handling of a request: (1) manual procedures which involve accepting the request, getting the requested item from library shelves and delivering it to the transmitting room, (2) actual transmission of the request, and (3) manual procedures following transmission which are concerned mainly with notifying the requestor that his material is ready to be picked up. The sum of the time required to accomplish these three stages is the service time.

The most significant time delay (because it is the longest) is the 4.2 hours associated with transmission. This is explained by the fact that the telefacsimile equipment operates at a fixed maximum rate. If the demand during a given period of time is less than this maximum rate, the excess capacity in the equipment cannot be used for other purposes, and that portion of the capacity which is not used during the period is lost. On the other hand, excess demand beyond the capacity of the equipment during a given period implies the accumulation of a backlog of material waiting for processing. This material will, of course, be transmitted in periods of low service demand to fill the excess capacity of the transmission equipment. Thus, one is faced with a situation where an attempt to reduce the waiting time will necessitate providing excess machine capacity (at additional cost). The reduction in service time becomes more costly when demands are concentrated into a few time intervals.

In all systems of this type there is a regular variation in hourly demand. During the experiment, this variation caused more than four hours of delay from the time the requested material arrived at the facsimile room until it was transmitted, even though the total request volume during the experiment amounted to only one-third of the total transmission capacity of the equipment.

The delays in the manual processing parts of the operation are caused by the same interplay of demand and capacity. Capacity, however, is not similarly fixed. The personnel are using skills which are similar to those applied to other portions of library operations. As a result, it may be possible to utilize these personnel both for other activities and for the telefacsimile system when the request rate requires it. In such a situation the additional cost of providing staffing to take care of a high level of demand with little delay does not create as much lost productive capacity in periods of low demand as would be the case if the personnel were dedicated solely to the telefacsimile operation.

This sharing of personnel must be carefully planned and executed. For the purposes of the experiment, this effort was not justified. Therefore, the personnel processing the requests prior to transmission were dedicated solely to the telefacsimile system. As a result, an average of two hours of delay was encountered from the time of the receipt of a request until the delivery of the requested material to the transmission room. By reorganizing this portion of the process so that requests are handled by the regular personnel of all of the branch libraries of the system, it is probable that at least one hour of this delay could be eliminated without a significant increase in system cost.

A second delay caused by manual processing was encountered during the period between the transmission of the material and the notification to the requestor that his material had arrived. This delay averaged two and one-half hours and was due primarily to an error in the design of the experiment. We incorrectly assumed that the person monitoring the facsimile receiver would also be able to perform other duties not related to the telefacsimile system. It developed, however, that the operator's two duties required more time than had been anticipated, with the result that LDX requests were not handled as expeditiously as we had expected.

It appears that the delay at the receiving end could be reduced to approximately one-half hour by dedicating a person full-time to the telefacsimile system. Thus, by reorganizing manual procedures at both ends of the operation, it would be possible to achieve an average service time of approximately six hours without employing additional equipment.

An assumption underlying the experiment was that the advantage of a telefacsimile system is its ability to provide rapid response to requests, and that its use can therefore be justified only if the delivery speed achieved is considered sufficiently important to justify the higher costs involved. During the study we obtained information about the importance to the requestors of fast delivery of the material. To do this we asked the requestor to evaluate the telefacsimile transmission versus surface delivery of the material, we observed the requestor's delay in picking up the telefacsimile material, and we compared the total demand volume during the experiment with the demand volume in the standard Interlibrary Loan system before and after the experiment.

The requestors responded that they wished to have the service available on those occasions when material was needed quickly. Their delay in picking up the telefacsimile material, however, averaged over seven hours. Finally, there was no marked change in demand during the experiment as compared with preceding and succeeding months. These data indicate that the work habits of the faculty are organized around the current operating systems and that a one-month experiment was not long enough for them to reorganize work habits built up over a period of years. It is likely that a considerable period of planned, continuous, reliable operation would be required before a person could reorganize his work habits to take advantage of high speed service.

The experiment was designed assuming that the requestor wanted his material as soon as possible. The delay in pick-up indicated that this assumption was incorrect, and the speed of response desired varied widely from one request to another. From this we can infer that some people wanted their material faster than others, and therefore, any system, whether telefacsimile or standard loan, should be designed to operate on a variable response basis. That is, at the time of the request the requestor should be asked the time by which he would like to have the material and the time beyond which it would not be of value to him. With this information, a priority scheduling could be developed to provide varying response times. It appears highly likely--although the data are not available to support this conclusion--that had we asked our requestors how soon they wanted the material, we could have diverted some requests from the telefacsimile equipment, and thereby improved the service time for those people who were genuinely in a hurry for their material. The diverted requests would have been delivered by surface transport to those who were not in a hurry.

There are two major aspects of the cost of responding to requests using telefacsimile equipment. The first is the fixed monthly cost regardless of the amount of volume on the system, and the second is a variable cost required to handle each of the requests in the system. From the experiment, we estimate monthly equipment costs to be approximately four thousand dollars.* Processing effort to handle individual requests was estimated at fifty minutes. Based upon a personnel cost of $2.40 per hour and a monthly volume of four hundred serviced requests of fifteen pages each, the average cost per serviced request is twelve dollars.

In an operational system with the personnel reorganization discussed above, the per page cost would be one dollar and the average service time would be approximately six, instead of nine hours, from the receipt of request to the time of notification. Given the level of demand and the variability in request rate that we experienced, it would be increasingly expensive to reduce the service time below six hours. Further, since four hours is absorbed in delay waiting for transmission capacity to be available, it would not be possible to reduce the delay period below four hours except by installing additional equipment or reducing the demand.

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* These costs are based on the regular commercial rates for the facsimile equipment and the communication link, and are not those paid during the experiment.

Additional capacity on the current equipment can be provided by operating the system on the second and third shifts. The effect of this is to reduce the number of working hours in which the requestor must wait for his material. However, even though the telefacsimile equipment is already installed, the variable costs of a second shift operation are higher than the cost of providing overnight service by surface transport. Thus, a telefacsimile system must be designed to provide same-day service in order to be competitive with other methods.

Should operational telefacsimile systems be implemented in libraries at this time? Because of their length, monographs in general should not be considered. For journal articles, our analysis indicates that a variable response system requires the same reorganization of manual procedures whether material delivery is by surface transport or by telefacsimile equipment. Therefore, the procedures should be reorganized and the system made to operate smoothly with surface transport before the investment in telefacsimile equipment is made. The only exception to this would be a situation in which the need for same-day service was evident and no surface transport methods were capable of meeting the time constraints. However, such a situation is likely to be rare since a variable response system could include air transport and special courier service to handle requests requiring fast response.

In order to gather useful information on the needs of requestors for rapid response, variable response systems incorporating both telefacsimile and surface transport should be operated on an experimental basis. Such experiments should be set up for long periods of time so that requestors could reorganize their work habits to make appropriate use of the system.

III. EXPERIMENTAL DESIGN

A. GENERAL DESCRIPTION

The experimental LDX system was operated from March 2, 1967 to March 31, 1967. This period included 21 full working days. Operation was on a nine-hour day basis beginning at 8:00 a.m. and closing at 5:00 p.m. The month also included an administrative holiday on Friday, March 24. No new requests entered the system on this day; however, the system was operated in order to transmit the backlog which had accumulated in the LDX room.

The experiment involved two campuses of the University of California--Berkeley and Davis. The transmitting station was located at Berkeley and the receiving station at Davis. This arrangement was made because the Berkeley-to-Davis link has the largest annual volume of inter-campus Interlibrary Loan transactions and also because the Davis Library has had previous experience in testing facsimile transmission equipment.* At each of the two campuses the LDX facility was located in the central library building. A block diagram showing the system configuration appears in Figure 3.

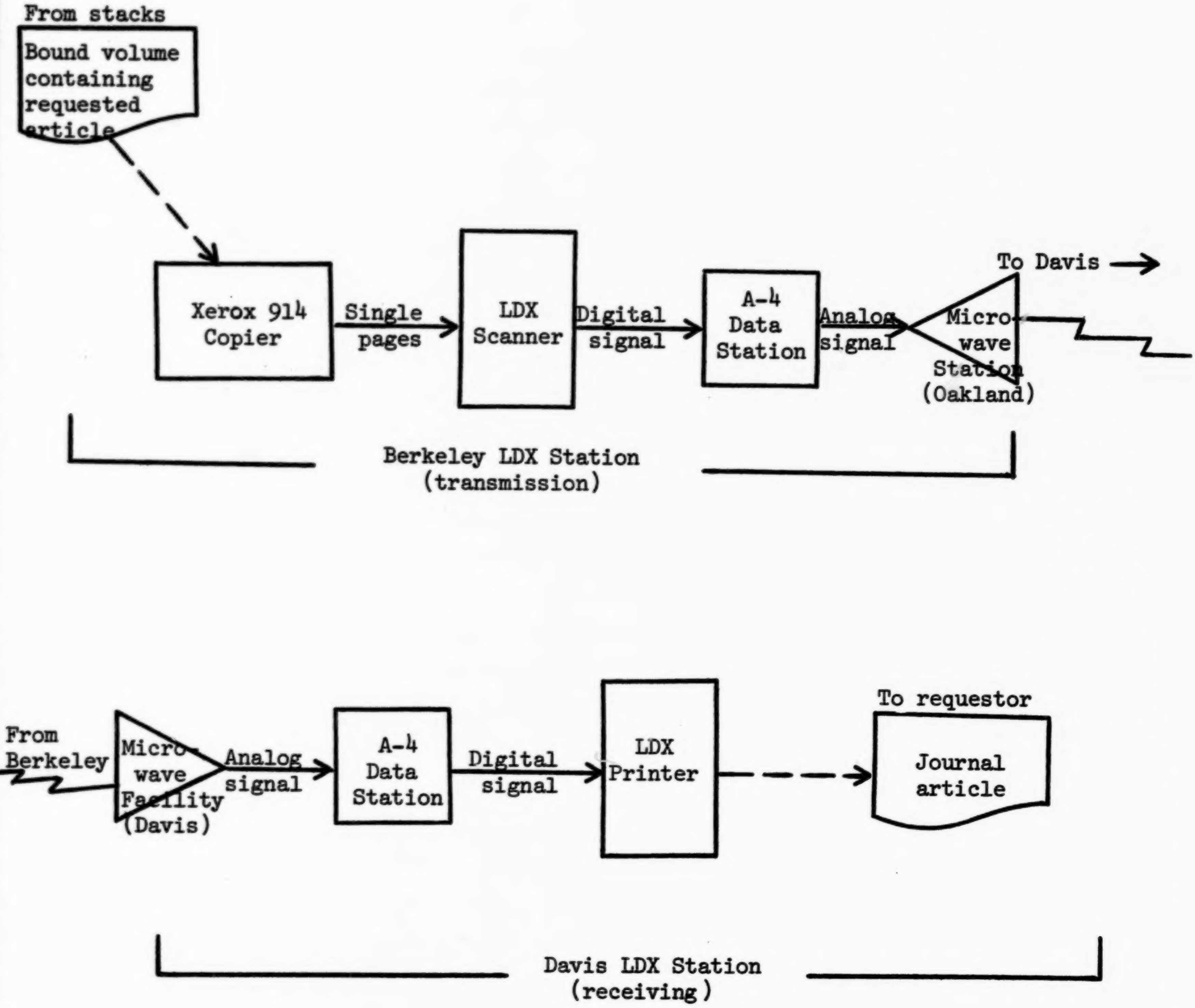
Two types of materials were transmitted during the test. The first type consisted of specially-selected copy which included a series of test patterns and examples of various type fonts. These materials were transmitted to enable us to evaluate the quality of the LDX copy. The second type of materials handled consisted of journal articles requested on Interlibrary Loan. Because of capacity limitations, we decided to service only those requests which were for articles of less than 100 pages in length.

The LDX test utilized a private-line cable/microwave facility leased from Pacific Telephone and Telegraph Company. The signal was transmitted over 48 KC channel (TELPAK A). In order to convert the LDX digital signal to an analog signal and back again, a broadband data station (Type A-4) was required at each LDX station. The transmission line components are also shown on the block diagram in Figure 3.

---

* A one-month test of Magnafax Telecopier equipment was conducted by the University of Nevada during Spring 1966. One link was operated between Nevada's Reno campus and the Davis campus of the University of California. See: Morehouse, Harold G., Telefacsimile Services Between Libraries with the Xerox Magnavox Telecopier, A Study Prepared for Council on Library Resources Inc., University of Nevada Library, Reno, Nevada, December 20, 1966.

FIGURE 3: LDX SYSTEM CONFIGURATION


From stacks
Bound volume containing requested article
Xerox 914 Copier
Single pages
LDX Scanner
Digital signal
A-4 Data Station
Analog signal
Micro-wave Station (Oakland)
To Davis
Berkeley LDX Station (transmission)
From Berkeley
Micro-wave Facility (Davis)
Analog signal
A-4 Data Station
Digital signal
LDX Printer
To requestor
Journal article
Davis LDX Station (receiving)

The physical route used during the test is presented in Figure 4 below.

FIGURE 4 : TRANSMISSION LINK ROUTE

FROM:	TO:	LINK
Berkeley	Thornwall Office	Wire
Thornwall Office (Berkeley)	Olympic Office	TV Cable
Olympic Office (Oakland)	East Hills Station	TV Cable
East Hills Station	Vaca Mountain	Microwave
Vaca Mountain	Davis	Microwave

B. PROCEDURES

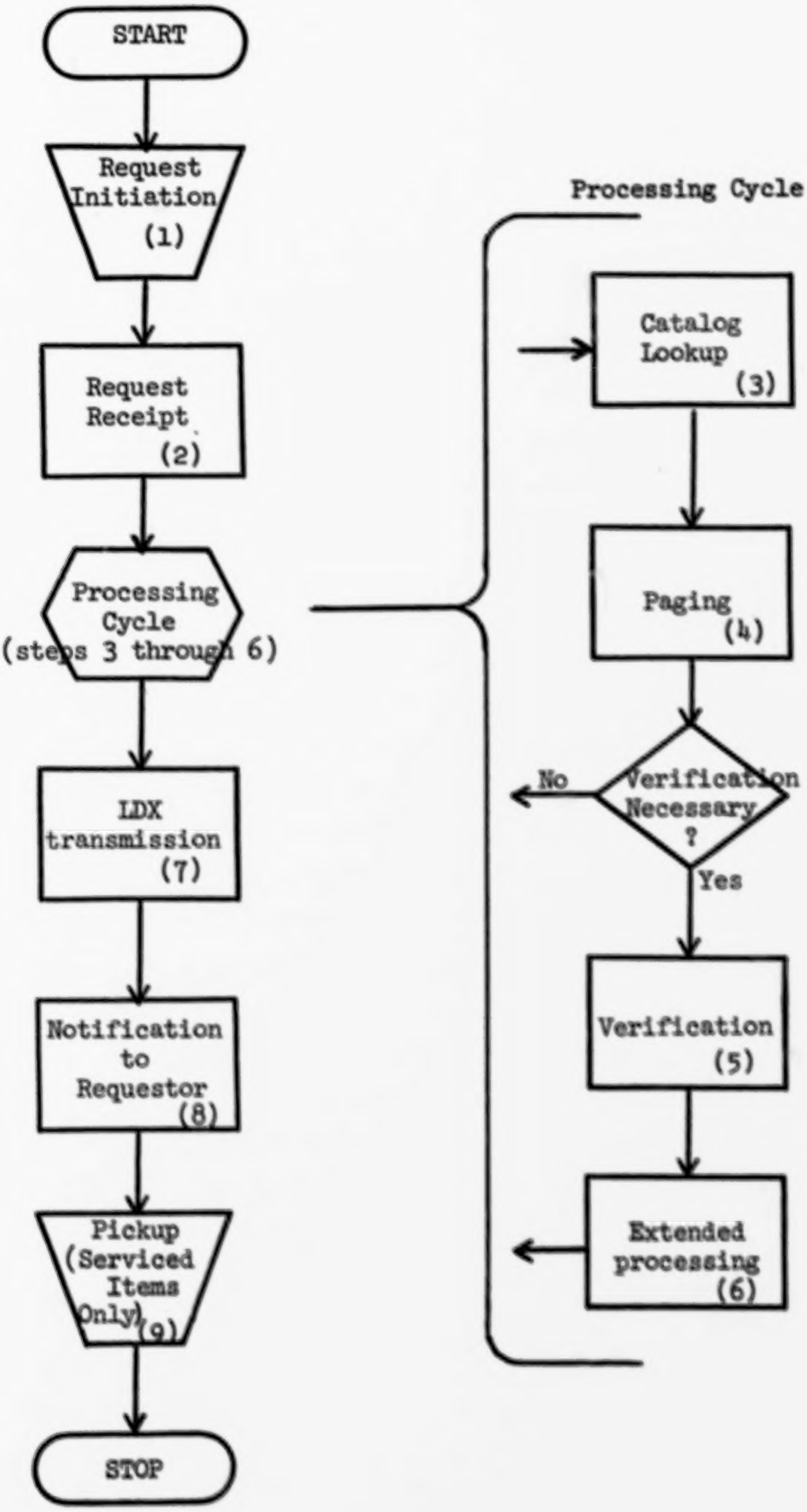
In order to evaluate the LDX system, it was necessary to design procedures which could be implemented in actual working conditions. Consequently, the procedures had to be responsive to individual requests, capable of handling the types of materials usually handled by Interlibrary Loan, and able to provide rapid access and rapid delivery which was compatible with the potential performance of the telefacsimile equipment.

The entire procedure for handling Interlibrary Loan requests consisted of ten distinct processing steps. These steps are listed below in the normal processing sequence for a single item. However, because more than one person was involved in running the test, it was possible for two (or more) processes to be performed simultaneously. A flow diagram (Figure 5) has been included which summarizes the processing steps.

(1) Request Initiation. Requests were initiated by faculty members, who either telephoned them directly to Berkeley (using the University's tie-line), or submitted them to the Interlibrary Loan facility at Davis. In the latter case, Davis Library personnel consulted the book catalog of the Berkeley Library collection to ascertain that the item in question was at Berkeley and then transmitted the request to the Institute over the tie-line.

(2) Request Receipt. Direct calls from the faculty were received in the Institute's offices at Berkeley. The person taking the call was

FIGURE 5: PROCEDURAL FLOW IN PROCESSING REQUESTS


START
Request Initiation (1)
Request Receipt (2)
Processing Cycle (steps 3 through 6)
LDX transmission (7)
Notification to Requestor (8)
Pickup (Serviced Items Only) (9)
STOP
Processing Cycle
Catalog Lookup (3)
Paging (4)
Verification Necessary ?
No
Yes
Verification (5)
Extended processing (6)

instructed to record the information given by the requestor, who had been asked to provide as much identifying information about the article as possible (journal title, author of article, call number, etc.) He was also asked his name, department and phone number. This information was recorded on a form which served as the control document for all stages of the operation.

(3) Location of Material. If the campus location (i.e., Main Library or branch) of the requested article was not given by the requestor, the page (i.e., the person retrieving the journal) first determined the location by consulting the public catalog. When all requests had been located, the page placed them into groups by location and selected what he considered to be the most efficient itinerary for retrieving them. A map showing the central and branch libraries has been included in Figure 6. In general, items were processed in batches rather than individually. Therefore, we will use the term "processing cycle" to refer to all work performed on a batch of requests during steps 3 through 6.

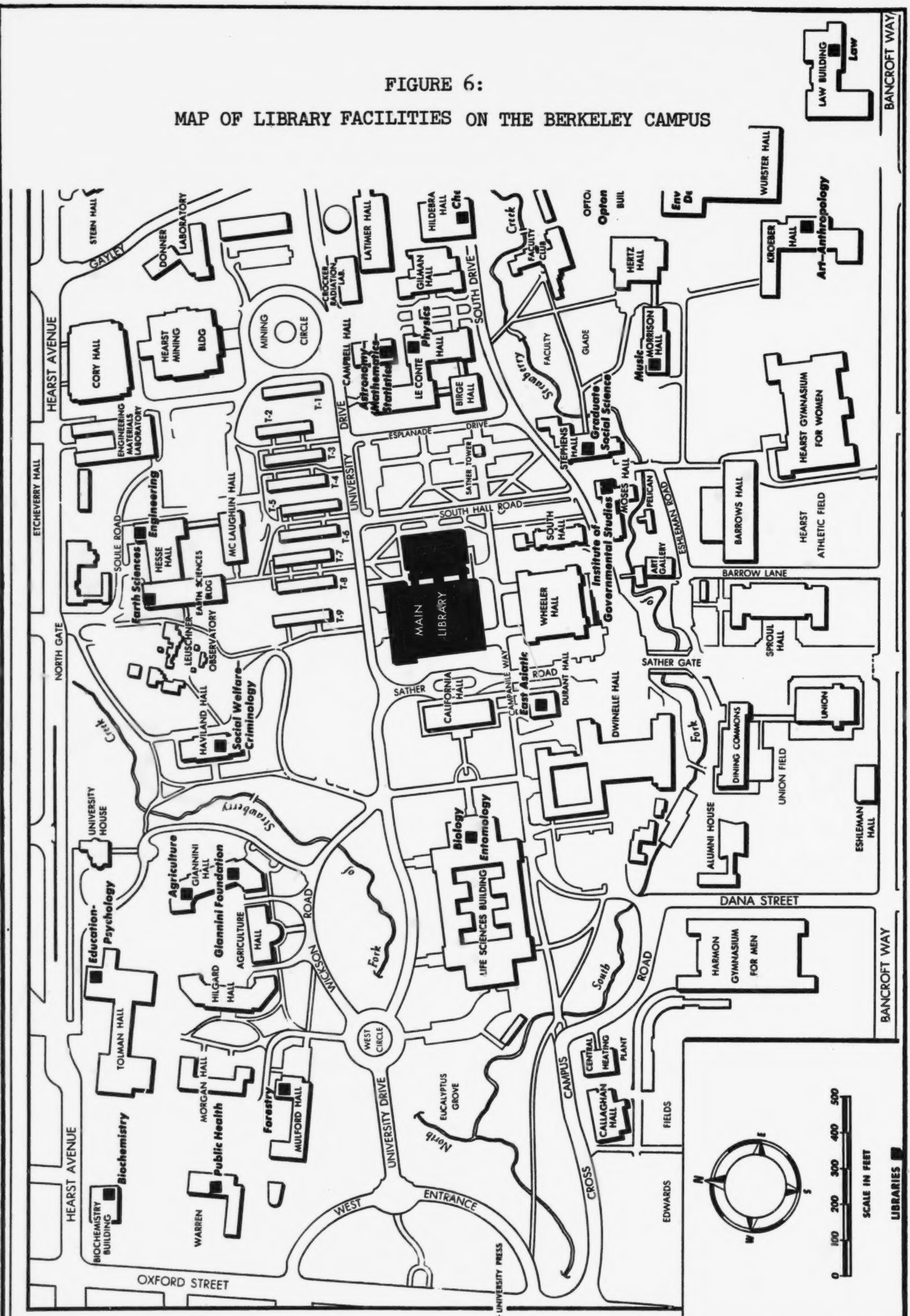
(4) Retrieval of Material (Paging). During this step, the page went to the various locations in order to obtain the requested journals. If all of the requests at a given location did not have call numbers, a lookup was done using the departmental catalog. The items were then paged from the stacks. Those items found on the shelf were charged out to the project; those not on the shelf were checked to determine whether further processing was possible. After all of the items in the batch had been processed, they were delivered to the LDX room.

(5) Verification. If one or more requests contained errors or incomplete information, the page verified these items in bibliographic sources. In some cases this was done at the remote location, but usually central library sources were used.

(6) Extended Processing. If, in verifying an item, the page was able to determine the correct citation, another try was made to find it. Additional catalog lookup and repaging were included in this category. Instances in which all or part of a journal article had to be recopied or retransmitted were also considered as extended processing.

FIGURE 6:

MAP OF LIBRARY FACILITIES ON THE BERKELEY CAMPUS


MAIN LIBRARY
Law
LAW BUILDING
Art—Anthropology
KROEBER HALL
Music
MORRISON HALL
Graduate Social Science
STEPHENS HALL
Institute of Governmental Studies
MOSES HALL
Physics
LE CONTE HALL
Astronomy-Mathematics-Statistics
CAMPBELL HALL
Engineering
HESSE HALL
Earth Sciences
EARTH SCIENCES BLDG
Social Welfare-Criminology
HAVILAND HALL
East Asiatic
DURANT HALL
Biology
Entomology
LIFE SCIENCES BUILDING
Education-Psychology
TOLMAN HALL
Agriculture
GIANNINI HALL
Giannini Foundation
Forestry
MULFORD HALL
Public Health
WARREN
Biochemistry
BIOCHEMISTRY BUILDING
Opton
HEARST AVENUE
BANCROFT WAY
OXFORD STREET
DANA STREET
UNIVERSITY DRIVE
SATHER GATE
NORTH GATE
WEST CIRCLE
MINING CIRCLE
WHEELER HALL
SOUTH HALL
CALIFORNIA HALL
DWINELLE HALL
SPROUL HALL
HEARST GYMNASIUM FOR WOMEN
HARMON GYMNASIUM FOR MEN
EUCALYPTUS GROVE
UNIVERSITY PRESS
SCALE IN FEET
0 100 200 300 400 500
LIBRARIES ■
N E S W

(7) LDX Transmission. At the end of the processing cycle, the page delivered the batch of requests to the LDX room at Berkeley. The bound volumes containing the requested articles were prepared for copying. Because the LDX Scanner accepts only single sheet input, the journal article first had to be photocopied. A Xerox 914 Copier was used for this purpose. Whenever possible, the operator copied two book pages per Xerox page. Following the copying operation, the article was placed in the waiting line to the Scanner and subsequently transmitted. After sending the request, the operator prepared the questionnaire and the standard Xerox 914 copy for delivery to the requestor via campus mail service. If requested material could not be located, the control document, marked to indicate that the request could not be serviced, was transmitted over the LDX as a report.

(8) Notification. This step of the operation was performed on the Davis campus at the LDX receiving station. Transmission was carried on continuously, producing single-sheet output which was processed by a clerk several times per hour. Processing included gathering the sheets which had accumulated in the LDX Printer output basket, collating each request, and checking to make certain that every item was complete. The clerk then notified the faculty member by phone that his request had been processed and was ready to be picked up. If a control document indicated that the request had not been serviced, the clerk routed the request to the Davis Interlibrary Loan staff for normal processing. If the non-serviceable request was one which the faculty member had placed directly (instead of through Interlibrary Loan) and he was expecting LDX service, he was notified at this time that his request had not been processed and was being forwarded instead to Interlibrary Loan.

(9) Pickup of Materials. Following notification, the serviced requests were taken to the Davis reference desk for pickup by the requestor. When the requestor arrived, he was asked to sign the control document and enter the date and time of pickup. These control sheets were retained for analysis upon completion of the experiment.

(10) Return of Materials. During the course of the day a large amount of journal material accumulated in the LDX transmitting facility at Berkeley. This material was held at the LDX room for a few days in case any retransmission was required. At the close of each working day, materials received three to four days earlier were returned to their locations to be reshelved by Library personnel.

C. OPERATION

Just prior to the starting date, the Davis faculty was notified by letter that the LDX service would be available for a one-month test. In this letter each faculty member was given detailed instructions on the use of the service (how to phone in a request, what information to give us, etc.). We asked that, if possible, he provide the call number of the requested item. The letter also indicated our expected turn-around time (4 working hours) and explained that if a request could not be serviced, it would be forwarded to the Davis Interlibrary Loan personnel, who would handle the request from that point. A copy of the letter and its attachment is included in Appendix II, Section B.

Based on current Interlibrary Loan volume averaging about 400 items per month (being serviced from Berkeley to Davis), half of which are requests for journal articles, we anticipated that we would have to handle about 200 transactions during the month, or about ten per day. From preliminary investigation, we expected that a transaction involving no special handling would take about one hour to service. Therefore, it seemed reasonable to expect that about 8 man-hours per day would be required to service a normal transaction at the transmitting end. To this we added an additional 50% time to allow for extended processing and other nonproductive time. According to this estimation, we would require the equivalent of one and one-half full-time people at Berkeley and one-half at Davis during the experiment.

Just prior to the test, the various people who were to run it were given a short training session. Each was given time to become familiar with the project procedures manual (see Appendix I). We then followed up with a short briefing session in which we attempted to relate the procedures to the objectives of the study.

People in three job positions were required to operate the experiment. Two of these were located at Berkeley and one at Davis. They were: (1) the project page (Berkeley), who picked up materials from the central library and branch locations;* (2) the LDX operator (Berkeley), whose function was to copy, transmit and return the material; and (3) the operator at Davis who handled the items which were received.

Several procedures were changed during the experiment as a result of experience. Initially, we thought that batching every hour would be necessary. Because of processing load, we used a less frequent cycle to allow the page to work with greater efficiency.

A second procedure requiring modification pertained to the type of material we would service. At first we placed no limitation other than the restriction of the service to requests for journal articles. It soon became evident that by trying to service very long articles, the consequent over-loading of the system caused service times to increase inordinately. We therefore decided to limit requests to journal articles which were less than 100 pages long.

Normally, serviced requests were transmitted via LDX. However, on several occasions the machine was inoperative ("down") for an extended period of time, sometimes as much as a full day. This, of course, created a backlog of requests to be transmitted. We had the choice of working overtime, of restricting the volume of incoming requests, or of transmitting the material by bus rather than by LDX. Because of limited funds, the first alternative--working overtime--was used only a few times. The second method was used more frequently toward the end of the experiment. On days when the system was overloaded, we limited the number of requests we would receive from the Davis Interlibrary Loan office, although no attempt was made to limit the number of direct requests. The third alternative--bypassing the transmission facility--was chosen twice when the equipment failed. The materials were placed on the Davis bus as usual, but no LDX copy was transmitted for these items.

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* If in the office, the page took the initial request. Otherwise, it was taken by one of the Institute staff.

Another procedural change was related to how the queues (the waiting lines to the machines) should be organized. What is said of the transmission queue also applies to the copying queue. After the operator had finished copying an article, it was placed in the transmission queue. If the machine was not being used, the queue was empty and transmission could begin at once. If the queue was not empty--that is, if other items were waiting to be transmitted--the new item was placed in the queue. During the first half of the experiment, items were removed from the queue on a "first-in, first-out" basis, regardless of the length of the item. Under this system, however, a 100-page article could delay the transmission of shorter requests for the duration of its transmission. In the second half of the experiment, an attempt was made to shorten the transmission waiting time by removing items from the queue on a "shortest-in, first-out" basis. Thus, the shorter articles are processed before the longer ones in the queue.

D. DATA COLLECTION AND ANALYSIS

1. General Objectives. In testing the LDX method of facsimile transmission, we wished to obtain information relating to three aspects of its feasibility:

a. The service characteristics of this prototype system. In this category are considerations of service time, queue characteristics, copy quality, and user response to the service.

b. The nature of the demand for an LDX facility. Without sufficient demand for high-speed access to materials, the cost of LDX facsimile transmission cannot be justified. It was our intent to collect data to determine both the present demand for such a service and to try to ascertain what the potential demand might be.

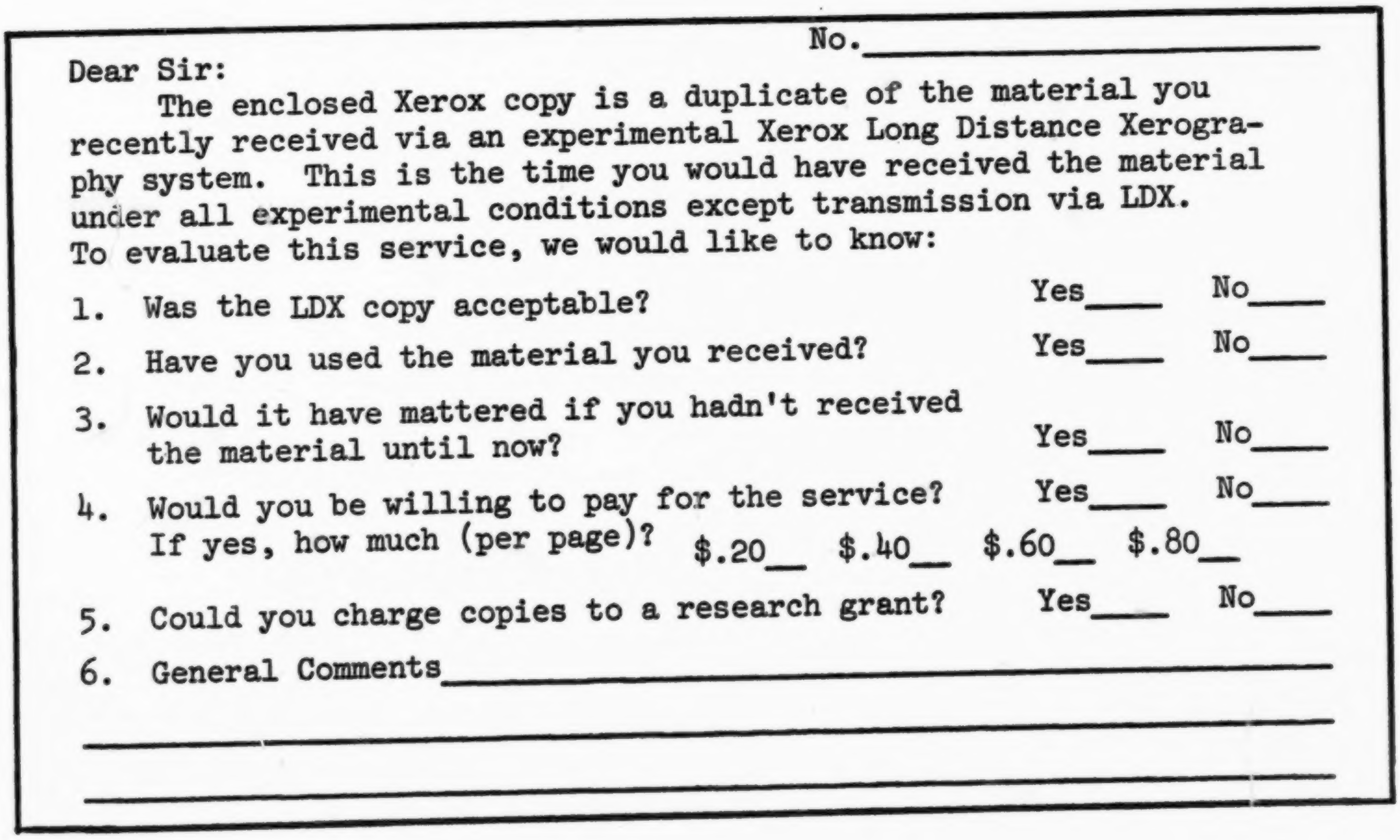
c. The cost of a typical facsimile system in a prototype library application. Considered here are the costs of the equipment, transmission lines and personnel.

Further, information about these three aspects--service, demand, and cost--had to be collected for individual requests and assembled in such a way that would allow them to be related. Data on the requests were obtained from users (through a questionnaire) and from the people who operated the experiment (through control forms). In addition, some data useful for comparing the facsimile system with both the current Interlibrary Loan system and a modified surface transport system were already available from other Institute studies.

2. The LDX Questionnaire. Information relating to the user's satisfaction with the LDX service and his actual (and potential) need for a facsimile system was obtained from a questionnaire which is reproduced in Figure 7. The questionnaire, asking the user, in effect, to compare a facsimile system with modified surface transport, was sent by bus along with the Xerox 914 copy.

The first question deals with the quality of the LDX copies. All others are designed to determine whether or not the user really wants, needs, or would be willing to support a facsimile system.

FIGURE 7: LDX QUESTIONNAIRE



No.________________

Dear Sir:

The enclosed Xerox copy is a duplicate of the material you recently received via an experimental Xerox Long Distance Xerography system. This is the time you would have received the material under all experimental conditions except transmission via LDX. To evaluate this service, we would like to know:

1. Was the LDX copy acceptable? Yes____ No____
2. Have you used the material you received? Yes____ No____
3. Would it have mattered if you hadn't received the material until now? Yes____ No____
4. Would you be willing to pay for the service? Yes____ No____
   If yes, how much (per page)? \$.20__ \$.40__ \$.60__ \$.80__
5. Could you charge copies to a research grant? Yes____ No____
6. General Comments________________________

3. The Control Forms. In order to obtain data pertinent to the operating environment, the people performing the work of the experiment were asked to record certain key items of information. Three separate forms were used--an item control sheet, a batch control sheet, and a transmission control sheet. Upon receipt of a request, whether obtained directly from the faculty member or from the Interlibrary Loan office, the person taking the call began an item control sheet, recording at this time information identifying the requestor and his request. The form used throughout the transaction is the control document on which all processing times were recorded. When the requested journal article was transmitted to Davis, a copy of the control sheet was also sent to provide full information about the item and the requestor for the receiving clerk. The item control sheet appears as Figure 8.

Two supplementary control forms were used. A batch control form was provided to record the processing times for each batch handled by the project page. For each step of the processing cycle, the page was asked to enter the time of day, the number of items contained in the batch, and the time of completion. A transmission control form was used by the operator to record copying times, transmission times and the number of pages for each transaction. These forms are shown on pages 111, 112, 113.

4. Data Analysis. Data obtained during the course of the experiment were prepared for machine analysis. The record of each request (the item control sheet) was coded for keypunching. An edit listing was made so that errors in coding and keypunching could be corrected. The corrected data were then placed on magnetic tapes for computer analysis.

Most of the computer programs used to analyze the data were University-supported statistical programs (Statpak). These programs are accurate and have a high degree of reliability. Distributions, correlations, etc., were provided using Statpak. The remainder of the machine-based analysis was obtained with special-purpose programs written by the Institute staff. Several analyses were done manually. A complete listing of all programs is given in Appendix II, Section A.

FIGURE 8: ITEM CONTROL SHEET

INSTITUTE OF LIBRARY RESEARCH
LDX PROJECT - ITEM CONTROL SHEET

Transaction number

☐ REA to:

Date

Batch

☐ Hold placed

Call number

Location

Date	Vol.	No.	Pages

Journal

Author (of article)

Title (of article)

Operation	Time in	Time out
Request receipt		
Catalog look-up		
Paging		
Copying (914)		
LDX transmission		
Verification		

Begin phoning

Time reached

No. of calls

Source of request

☐ ILL ☐ Direct

Request ☐ Serviced ☐ Not Serviced

Requestor

Department

Status

Telephone

Tie line ☐ Time ☐ No. tries

Source

☐ Material not sent because:

- ☐ NOS ☐ NICF ☐ DNC
- ☐ Not in CU (verified)
- ☐ Not in sources checked
- ☐ Incomplete info.____________
- ☐ Other____________

☐ Verification done

☐ Main
- ☐ ULS
- ☐ NST/LC
- ☐ CU Bk Cat.
- ☐ Serials
- ☐ Other______

☐ Local
- ☐ REQ
- ☐ Cat/Libn.
- ☐ Other ______

Materials received by:

X ________________________

Date

Time

IV. STUDY RESULTS

A. OPERATING CHARACTERISTICS

This sub-section provides the analysis of the direct measurements taken during the experiment. Results pertaining to general characteristics are included in part 1. The relationship of service times to processing times (i.e., man-effort) is analysed in part 2. Finally, the relationship of queuing and batching patterns to processing times is discussed in part 3. Indirect measurements, the demand for the service and the cost of the service, are analyzed in the later sub-sections.

1. System Volumes and Capacities. The one-month test of LDX involved twenty-one working days of operation. During this period, a total of 534 Interlibrary Loan requests was received, of which fifty-two were not processed through the facsimile system because of equipment failure. The remaining 482 requests provided the data for most of the analyses in this section.

Figure 9 summarizes the source of the requests and whether or not they were serviced. Note that only 22% of the total requests were received directly from the requestor; the remaining 78% were placed with the Davis Interlibrary Loan staff and transferred to us for LDX service. In this table, and throughout the report, we refer to "serviced" and "non-serviced" requests. A serviced request is a transaction in which the requested material was provided to the faculty member; a non-serviced request was one in which we were not able to supply the material requested. Note that "Requests handled via LDX" means both those requests in response to which the requested material was transmitted via LDX, and those in which only a notification of inability to supply the material was transmitted. The number of requests serviced totaled 376; the average number of pages per request was 14.2.

FIGURE 9: NUMBER OF REQUESTS HANDLED VIA LDX, BY RESULT OF SERVICE AND SOURCE OF REQUEST

Result of Service	Source of Request				All Requests	
	Direct from Requestor		Interlibrary Loan Office			
	Number	%	Number	%	Number	%
Serviced Requests	75	69.4	301	80.5	376	78.0
Non-serviced Requests	33	30.6	73	19.5	106	22.0
Total	108	100.0	374	100.0	482	100.0
Percent All Requests	22.4		77.6		100.0	

Figure 9 shows that it was not possible to provide the desired materials in 20% of the cases when the request came through Interlibrary Loan channels, and in 31% of the cases when the request came directly from the patron. This 50% higher failure rate on direct requests is explained by the fact that these do not receive the extensive verification and checking that ILL requests receive. As a result, failures due to the fact that the item requested was not in the Berkeley collection, or that the bibliographic information supplied was inadequate, were much more frequent in the case of direct requests. It is to be expected that in a continuing operation, with most requests being placed directly, a similar level of failure would probably be experienced, for the same reasons.

The causes of failure to provide requested material are analyzed in Figure 10.

FIGURE 10:

CAUSES OF FAILURE TO SERVICE REQUEST,
BY SOURCE OF REQUEST: INTERLIBRARY
LOAN (ILL) & DIRECT (D)

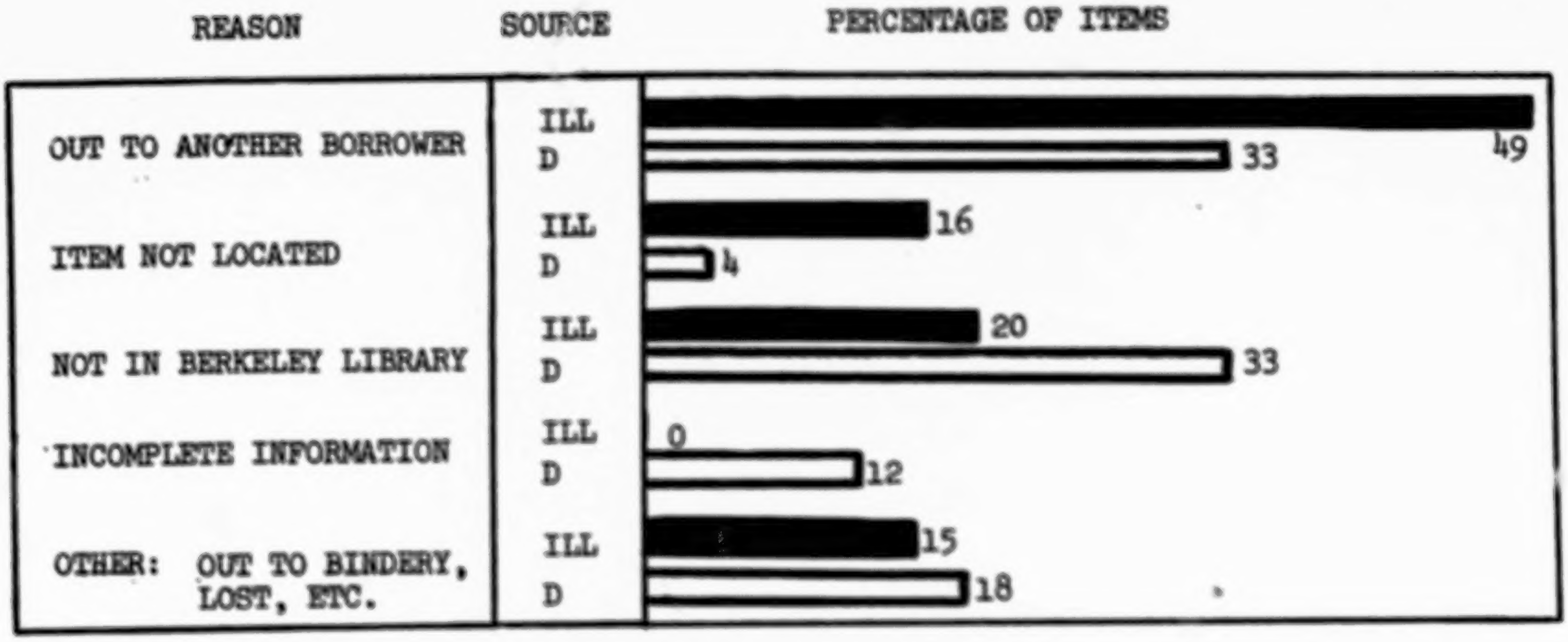


Figure 11 shows the pattern of system input and output for each day of the test. Days during which the machine was down show output volumes of zero (9 and 13 March). An administrative holiday (24 March), on which a backlog was transmitted, shows no receipts.

One of the most striking things observed is the disparity between the computed capacity of the machine and the actual throughput rate which we were able to achieve. If transmission could be carried out uninterruptedly for an eight-hour period the calculated throughput rate is 840 pages. On no day during this test, however, were we able to achieve a rate of greater than 60% of computed capacity; the average utilization was about 35% of computed capacity. Figure 12 shows the number of days during which transmission exceeded the given per cent of transmission rate.

FIGURE 11: DAILY DISTRIBUTION OF VOLUME
OF REQUESTS RECEIVED AND VOLUME OF PAGES TRANSMITTED

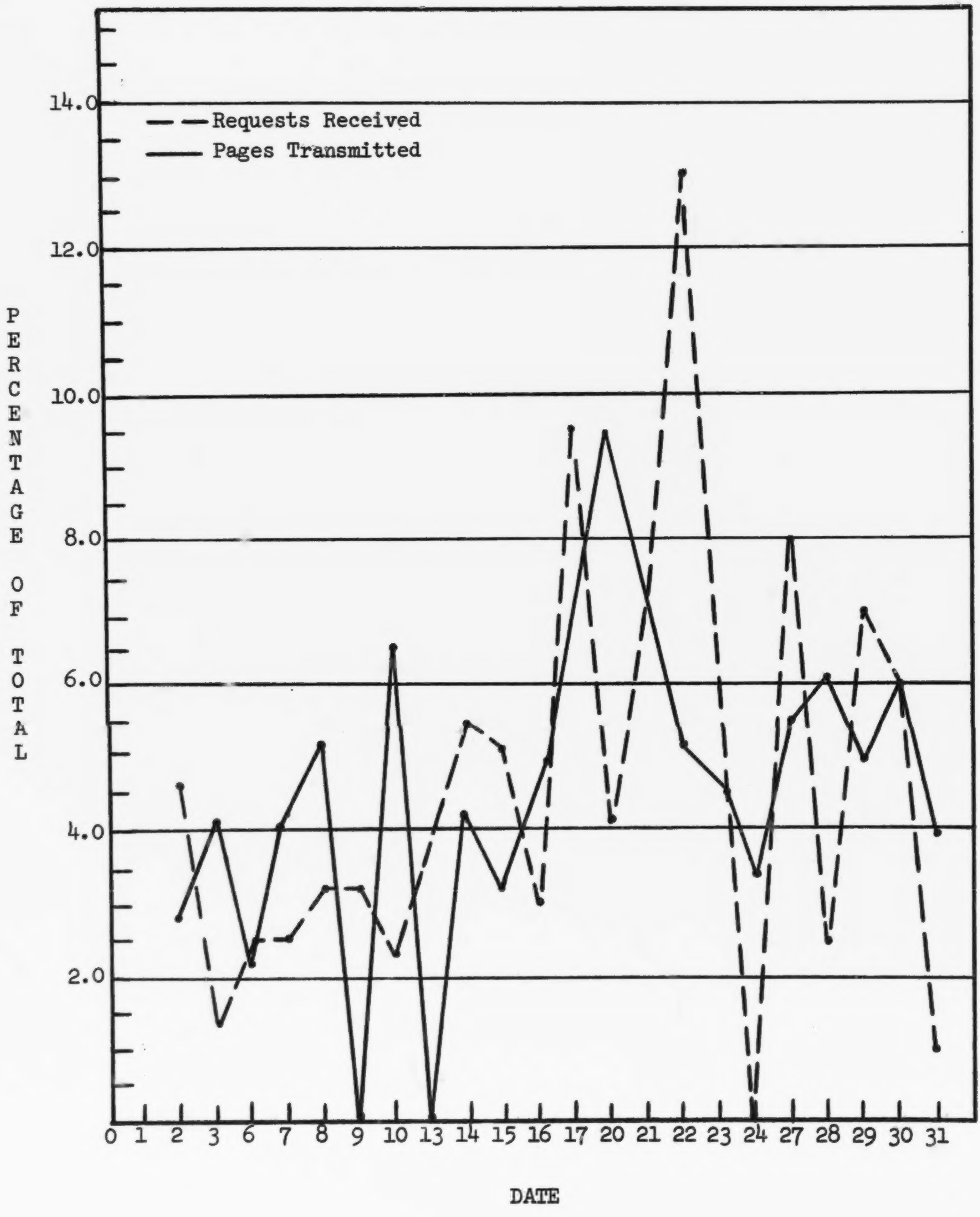
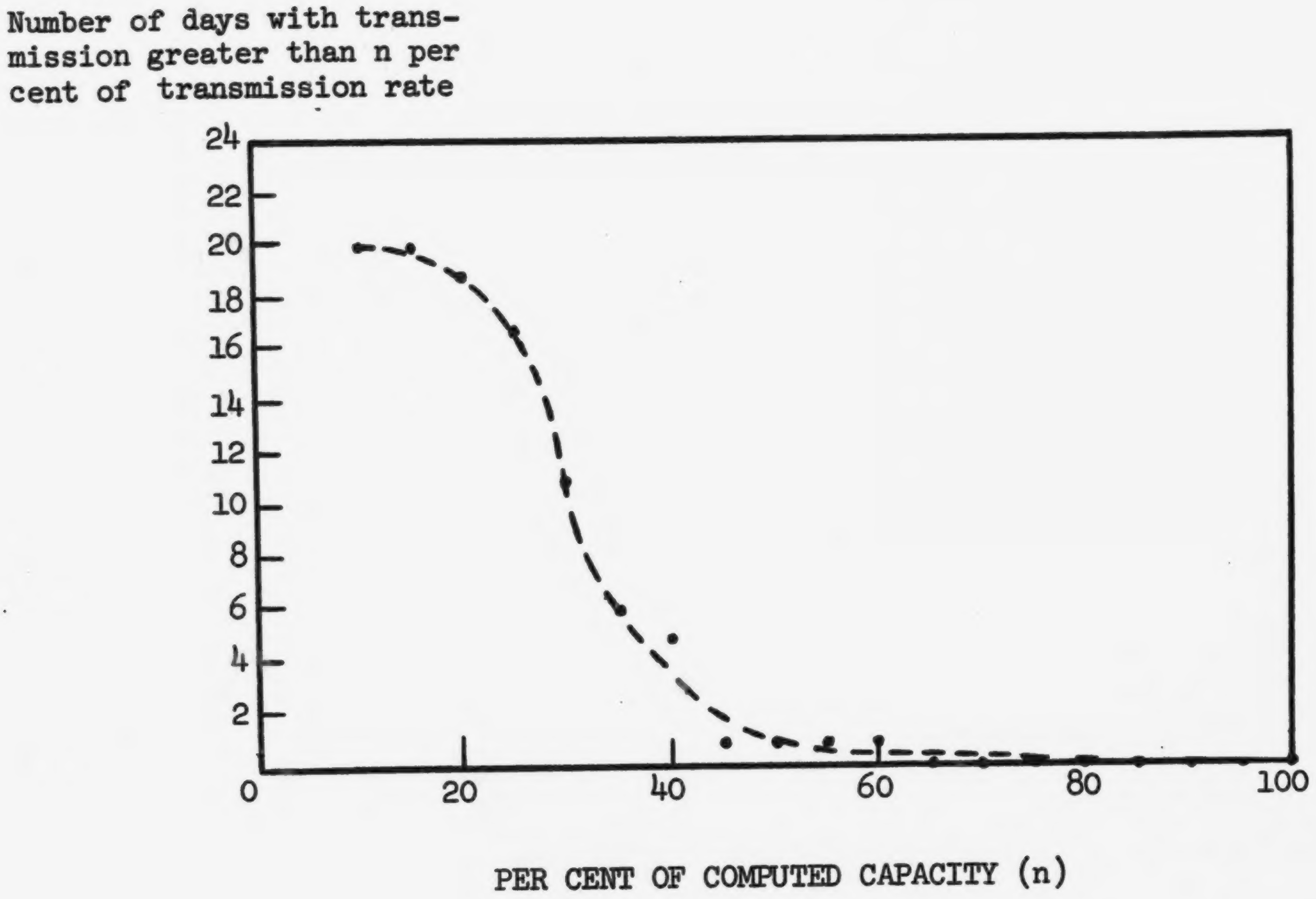


FIGURE 12: MACHINE UTILIZATION,
IN TERMS OF PER CENT OF TRANSMISSION RATE



In general, performance of the equipment was fair, although a relatively large amount of down time was experienced during the month. Instances exceeding one hour have been listed in Figure 13. Difficulty was also experienced because the automatic document feeder was not operated properly. At these times, paper jams caused us to remove the device and feed the document pages by hand to the Scanner one at a time. Although this procedure had little effect on the capacity of the system, it was a nuisance because of the close surveillance required.

FIGURE 13: SUMMARY OF DOWN TIME
INCURRED DURING EXPERIMENT

Date of Failure	Type of Failure	Hours	Reason for Failure
8	LDX Printer	1:00	Paper cutter malfunction
9	Phone line	9:00	Repeater station down
13	Personnel	5:00	Personnel absent at Davis
13	Phone line	4:00	Repeater station down
14	LDX Scanner	1:00	Photomultiplier malfunction
16	LDX Scanner	5:00	Photomultiplier malfunction
21	LDX Scanner	2:20	Jitter in transmitter
27	LDX Printer	1:15	Paper cutter malfunction
30	LDX Printer	3:00	Large amounts of retransmission caused by difficulties with paper cutter

2. The Relationship of Service Times to Processing Effort. A prime consideration in using facsimile as a means of transmitting library materials is speed of access. We wished to know how fast the material could be placed in the hands of the user (the average service time), and the amount of actual man-time required to process a request.

A chart (Figure 14) shows the relationship of these two important service-related characteristics--service time and processing effort. It shows total service time in terms of its two components--processing intervals and waiting intervals.* The processing intervals represent the man-effort--that is, the time for the staff to perform some process on the transaction. During waiting intervals no such processing is performed. From the chart it is apparent that by far the major portion of time is spent in waiting lines. It is very significant that the pickup wait interval (elapsed time between notification and pickup) accounted for 45% of the total service time (interval from request receipt to pickup).

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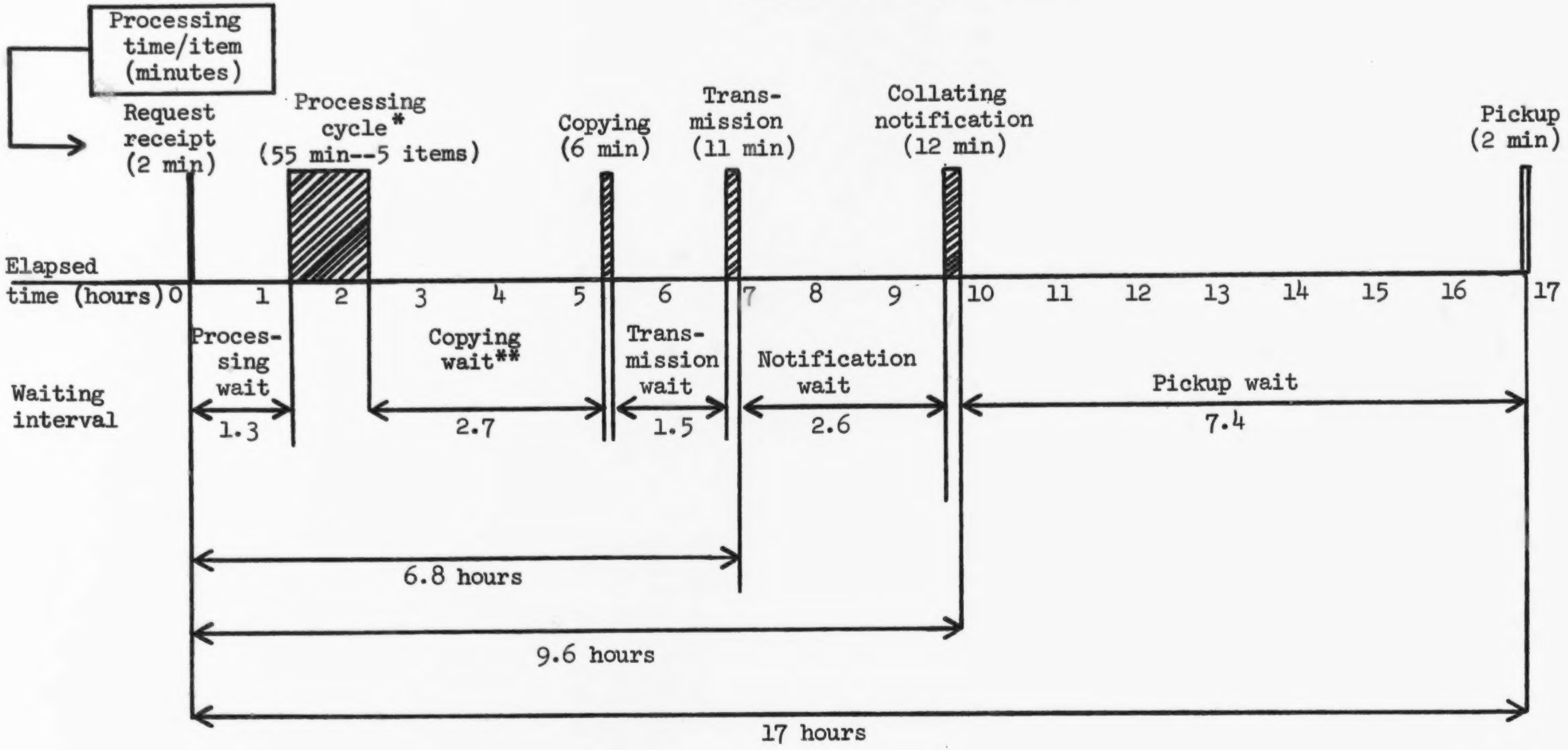
* The times shown in Figure 14 were calculated on a 9-hour basis; an explanation of how these times were calculated is given on page 34.

FIGURE 14:

SUMMARY OF AVERAGE LDX SERVICE TIMES,
IN TERMS OF PROCESSING EFFORT AND WAITING TIMES
(9-hour-day basis)


Processing time/item (minutes)
Request receipt (2 min)
Processing cycle* (55 min--5 items)
Copying (6 min)
Trans-mission (11 min)
Collating notification (12 min)
Pickup (2 min)
Elapsed time (hours)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Waiting interval
Proces-sing wait
1.3
Copying wait**
2.7
Trans-mission wait
1.5
Notification wait
2.6
Pickup wait
7.4
6.8 hours
9.6 hours
17 hours

* Processing time/item = 11 minutes.

** Copying wait is actually part of the transmission wait, since the copying equipment was faster and could readily keep ahead of the transmission equipment. Thus the addition of copy equipment would not reduce the wait time.

We have presented five service-time intervals. For direct requests the basic internal service-time interval is the one between the time the requestor places his request (request receipt at Berkeley) and the time he is notified that the material is ready to be picked up. In the case of requests received through Interlibrary Loan, the beginning of the service time interval was measured from the time that the Davis ILL transferred the request to us over the telephone. This interval is composed of two other periods: (1) request receipt to the end of transmission, and (2) end of transmission to notification. The fourth interval extends from notification to pickup. Finally, we have combined the first and fourth intervals to make up a total service-time interval, calculated from request receipt to pickup of materials. Diagrams of the following service-time intervals are shown in Figure 15 (9-hour-day calculation) and in Figure 16 (24-hour-day calculation):

Interval	
A	Request receipt to notification of requestor.
B	Request receipt to end of transmission.
C	Transmission to notification of requestor.
D	Notification of requestor to pickup of materials.
E	Total service time from request receipt to pickup of materials by requestor.

Mean service times have been calculated on both a 9-hour-day basis and on a 24-hour-day basis. In calculating intervals on a 9-hour-day basis we have not included time which is not part of the working day (i.e., before 8 a.m. or after 5 p.m.). Thus, for example, if a request was received Monday at 12:30 p.m. and the requestor notified on Tuesday at 9:45 a.m., Interval A for this item is 6 hours and 15 minutes on a 9-hour-day basis, and 21 hours and 15 minutes on a 24-hour-day basis. The five service-time intervals have also been calculated for each week of the experiment. These are shown in tabular form in Figure 17.

FIGURE 15:
AVERAGE SERVICE-TIME INTERVALS
(9-hour-day basis)

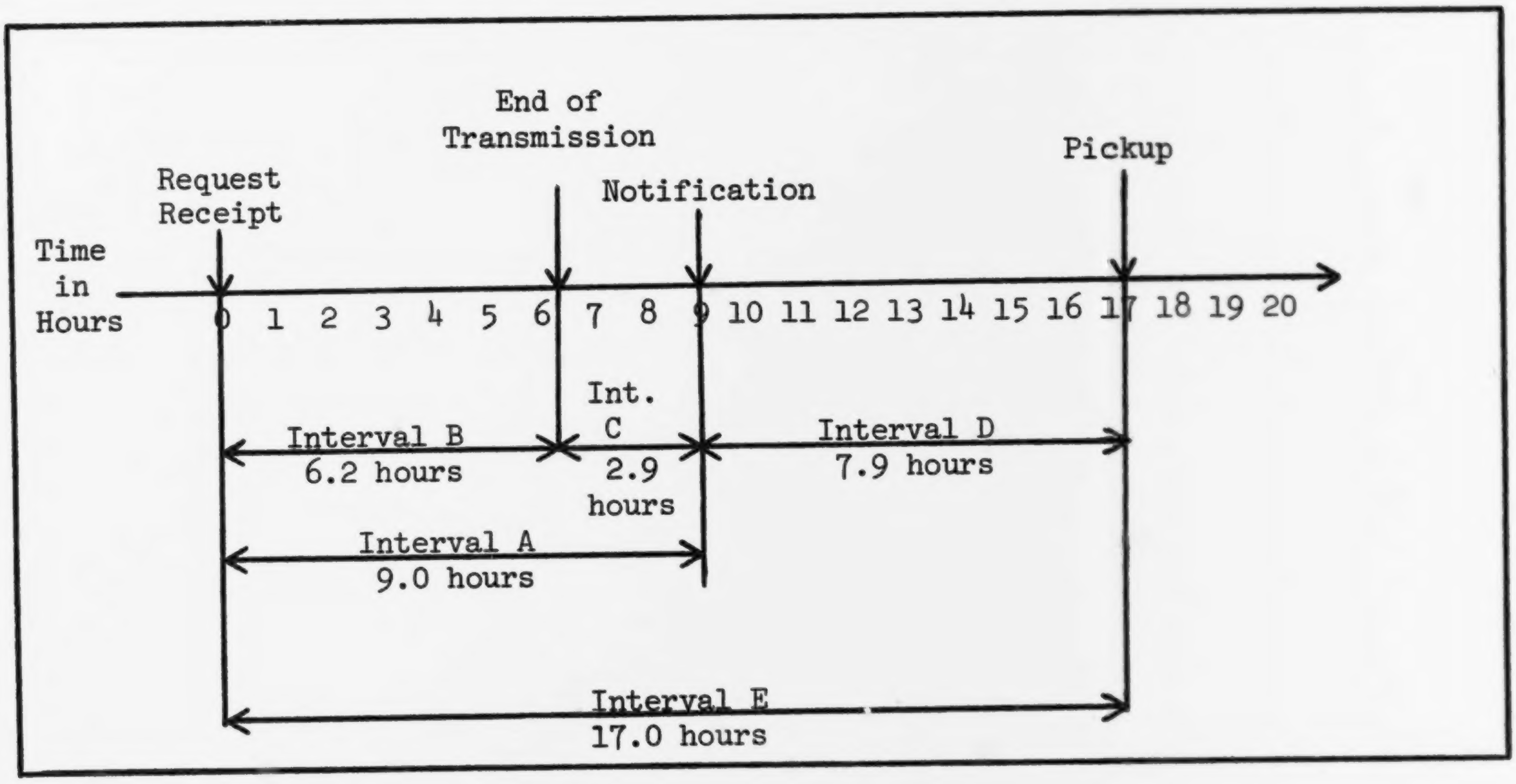

Time in Hours
Request Receipt
End of Transmission
Notification
Pickup
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Interval B
6.2 hours
Int. C
2.9 hours
Interval D
7.9 hours
Interval A
9.0 hours
Interval E
17.0 hours

FIGURE 16:
AVERAGE SERVICE-TIME INTERVALS
(24-hour-day basis)

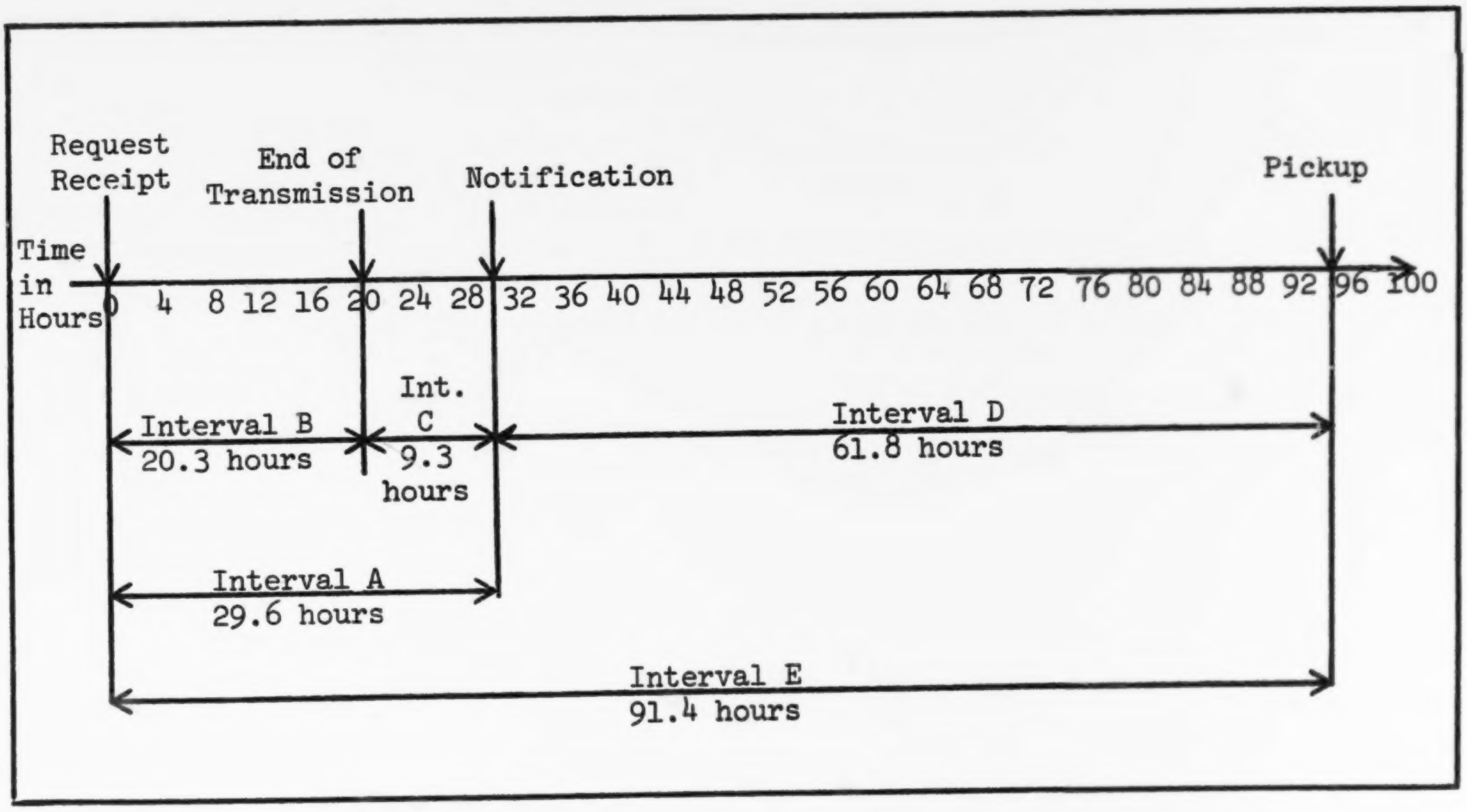

Time in Hours
Request Receipt
End of Transmission
Notification
Pickup
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76 80 84 88 92 96 100
Interval B
20.3 hours
Int. C
9.3 hours
Interval D
61.8 hours
Interval A
29.6 hours
Interval E
91.4 hours

FIGURE 17: SUMMARY OF SERVICE-TIME INTERVALS

(Times in Hours)

	Interval	Basis	Week of Experiment								All Weeks	
			First n=92		Second n=128		Third n=135		Fourth n=127		Average	
			Avg. Time	Stan. Error*	Avg. Time	Stan. Error	Avg. Time	Stan. Error	Avg. Time	Stan. Error	Avg. Time	Stan. Error
A	Request receipt to notification	9-hour	7.3	.63	8.3	.36	12.1	1.34	9.6	.42	9.0	.37
		24-hour	19.9	.63	35.5	2.90	43.9	5.66	21.2	1.13	29.6	1.72
B	Request receipt to end of transmission	9-hour	5.9	.37	6.9	.31	6.3	.53	6.1	.26	6.2	.17
		24-hour	15.1	1.4	32.3	2.42	17.2	2.32	16.1	.86	20.3	.97
C	End transmission to notification	9-hour	1.4	--	1.3	--	5.8	--	3.5	--	2.9	--
		24-hour	4.9	--	3.2	--	26.7	--	5.1	--	9.3	--
D	Notification to pickup	9-hour	5.2	--	6.5	--	13.2	--	4.1	--	7.9	--
		24-hour	56.8	--	80.5	--	84.6	--	18.9	--	61.8	--
E	Total Time: request receipt to pickup	9-hour	12.6	1.74	14.8	1.15	25.3	1.73	13.7	.91	17.0	.78
		24-hour	76.7	17.57	116.0	18.04	128.4	14.81	40.1	5.32	91.4	7.53

* Stan. Error = Standard Error

The amount of staff time which was expended in processing a typical transaction was determined by calculating the sum of the average times required to perform each of the processing steps. Two means are presented: the mean time required to complete an operation and the mean time per transaction, which is weighted by the frequency of occurrence of the processing operation. Because some steps may be omitted in processing a transaction, we are concerned mainly with the mean time per transaction over the entire set. To illustrate: verification takes an average time of 6.9 minutes, but the process is only performed 10.8% of the time. Therefore, the mean time per transaction over the entire set is 1.2 minutes. Transport time has been calculated by taking the mean time for the entire processing cycle and subtracting the sum of the times of service operations. The processing times are given in Figure 18.

FIGURE 18: SUMMARY OF PROCESSING EFFORT

Operation	Campus	Number of Items	Frequency	Avg. Time per Operation	Stan. Dev.*	Avg. Time per Transaction
Request receipt	B	482	1.000	2.0	1.9	2.0
Processing cycle:						
Look-up	B	225	0.467	3.1	4.1	1.4
Paging	B	463	0.961	5.0	5.9	4.8
Extended processing	B	52	0.108	9.4	20.8	1.0
Verification	B	81	0.168	6.9	10.9	1.2
Transport time	B	482	1/batch	2.7	--	2.7
Total, processing cycle						11.1
Copying	B	376	0.780	7.3	11.2	5.7
Transmission	B	482	1.000	10.8	23.7	10.8
Collation and notification	D	482	1.000	10.0	--	10.0
Pickup	D	376	0.780	2.0	--	1.6
Subtotal	---	482	---	--	--	41.1
Non-productive time (25%)	B,D	482	1.000	10.3	--	10.3
Total	---	482	---	--	--	51.4

* Stan. Dev. = Standard Deviation

3. Queue Characteristics and the Effect of Batching. One of the most critical aspects of this operation is the length of waiting-time intervals. These represent delay times during which a request is not being directly processed. Items waiting to be processed are said to be in the queue. Items are placed in the queue at the time they are output from the preceding process and removed from the queue when they are input to the next process. If the page picks up a batch to begin a new processing cycle every two hours, for example, all requests which are received after the page has left, and before he returns two hours later, must wait. Thus, in this case, the waiting time of an individual request may vary anywhere from a minimum of zero to a maximum of two hours.

a. Processing wait. This interval is the time between request receipt and the beginning of the processing cycle.

b. Copying and transmission wait. This interval extends from the time a batch containing the item was delivered to the LDX room to the time its transmission was begun. Although this wait consists of two distinct intervals--the copying wait interval and the interval which begins when the copying is completed--we will consider this solely as transmission delay since the copy machine ran considerably faster than the LDX. Thus the copy wait shown is actually a wait for LDX transmission. The entire interval will be referred to as the delay in the transmission queue.

c. Notification wait. This interval extends from the end of transmission to the time when the requestor is notified that his material is ready. It applies alike to serviced items and non-serviced requests which were received directly from the requestor.

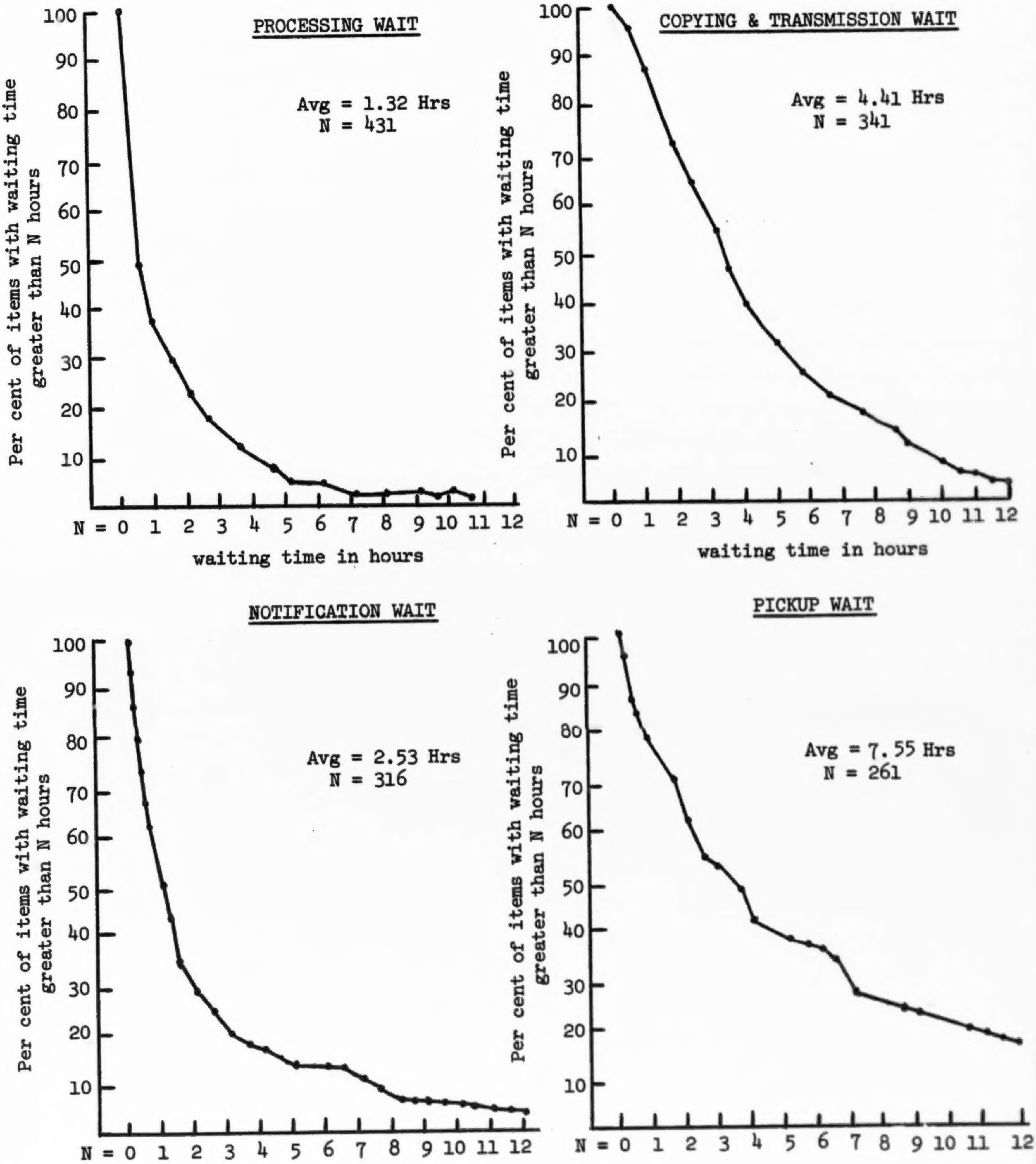
d. Pickup wait. This interval, applying only to serviced items, extends from notification to pickup of materials.

Distribution of waiting times in each of these four queues are presented in Figure 19. Relationship is in terms of per cent of items which have waiting times greater than some given number of hours (shown on the horizontal axis). For example, in the graph showing the processing wait, 22% of the items had a processing wait of greater than two hours.

It is obvious that the transmission queue caused the greatest amount of delay in servicing requests. Figure 20 shows the relationship between

FIGURE 19:

DISTRIBUTION OF WAITING TIMES

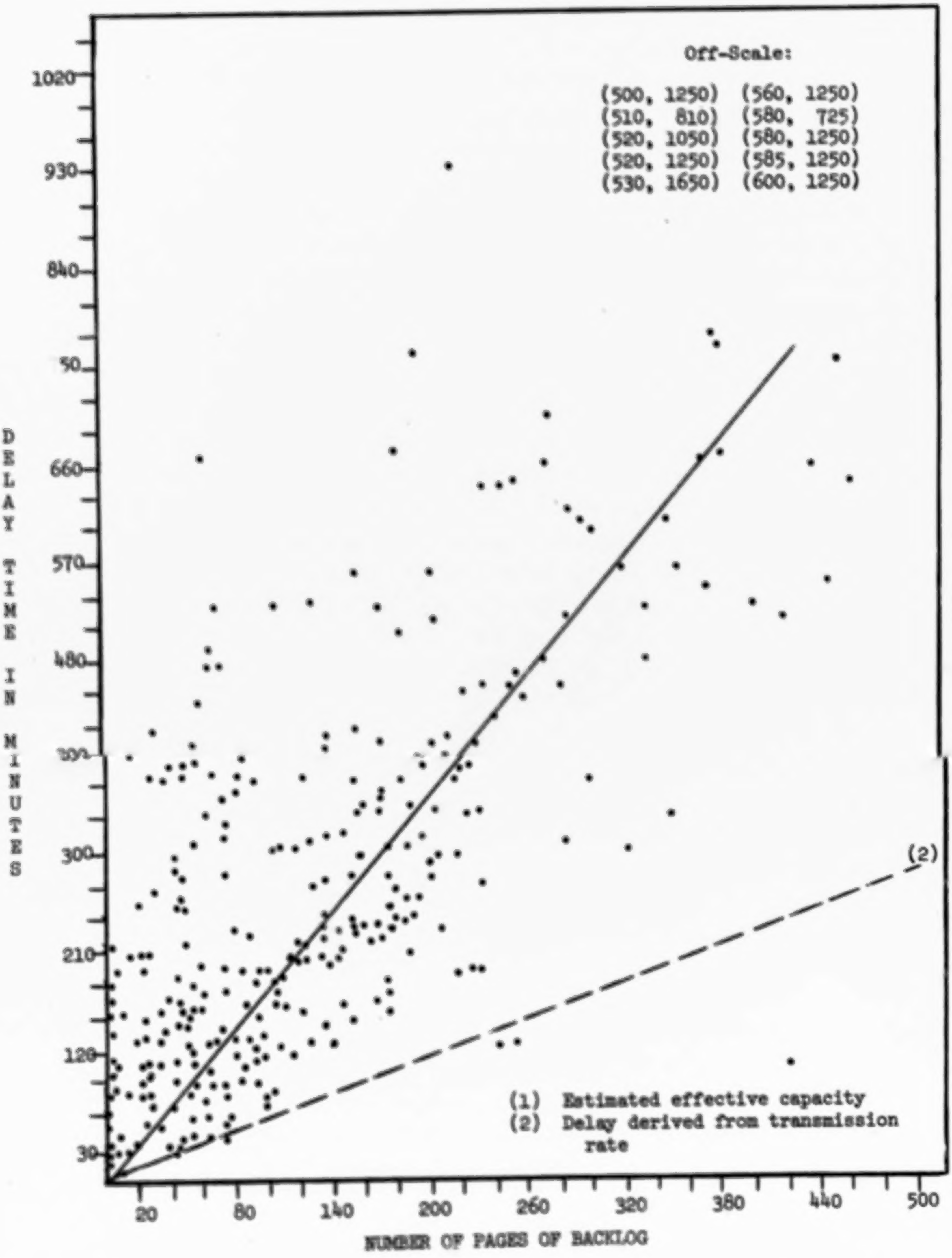


the amount of system volume and the time delay encountered in the transmission queue. The times shown were calculated on a 9-hour-day basis. In Figure 20 we have shown the amount of delay in the transmission queue as a function of system load, measured in terms of number of pages of backlog. For any given period of time the maximum capacity of the machine can be calculated. For example, in one hour, a maximum of 105 pages can be transmitted. If the system load during the period exceeds this maximum, an overload condition exists, and the queue of items waiting to be transmitted grows longer. This is, in fact, the pattern that the data show.

Graphing this function was made difficult by the fact that the system did not operate smoothly. For example, in the early part of the experiment we experienced considerable down time, and had many interruptions. In addition, the priority system of "first-in, first-out" was not enforced. In order to reveal what we believe is an extremely important relationship, we have attempted to correct to normal by taking the liberty of omitting data which are obviously not representative. Thus, all transactions which arrived for service when the machine was down were omitted from the calculations.

Using these results we interpret the solid curve (1) to represent the transmission capacity under normal operating conditions. If the equipment could be operated continuously at its basic transmission rate, the dashed curve (2) would represent the relationship between the number of pages of backlog and the transmission delay.

FIGURE 20: TRANSMISSION DELAY TIME
AS A FUNCTION OF BACKLOG



Requests were transmitted on a "first-in, first-out" basis during the first three weeks of operation, and on a "shortest-in, first-out" basis during the final week. No significant changes were made in other request-handling procedures. By comparing the average transmission waiting times for the third and fourth weeks, evidence of the relative efficiency of these two strategies was obtained. The average waiting time of 2-3/4 hours for the third week was reduced to 2 hours in the fourth week. We conclude, therefore, that the strategy of "shortest-in, first-out" effectively reduced the average waiting time in the transmission queue.

During the processing cycle, items were batched. In this part of the analysis, we have attempted to determine what effect batching had on the time required to process a transaction. We expected that processing time per transaction would decrease with increasing batch size. However, since the number of paging locations within a batch affected processing cycle times, this was not always the case. Thus, cycle times became a function of the number of items paged (where paging time is a fixed time per item), the number of locations (where transport time per location is fixed), and an unknown constant representing the average amount of time spent in look-up, verification and extended processing. Expressed mathematically, this relationship is:

$$T = k_o + k_1x_1 + k_2x_2$$

where:

T = total processing cycle time = 55.37 min./batch

k_o = constant, representing the average time for look-up, verification and extended processing = unknown

k_1 = average fixed processing time per item (paging time) = unknown

x_1 = average number of items per batch = 4.97 items/batch

k_2 = average fixed transport time per item = unknown

x_2 = average number of locations per batch = 2.21 locations/batch

A stepwise regression was run to determine the value of the unknowns. The result was that:

k_o = 16.63 minutes/batch

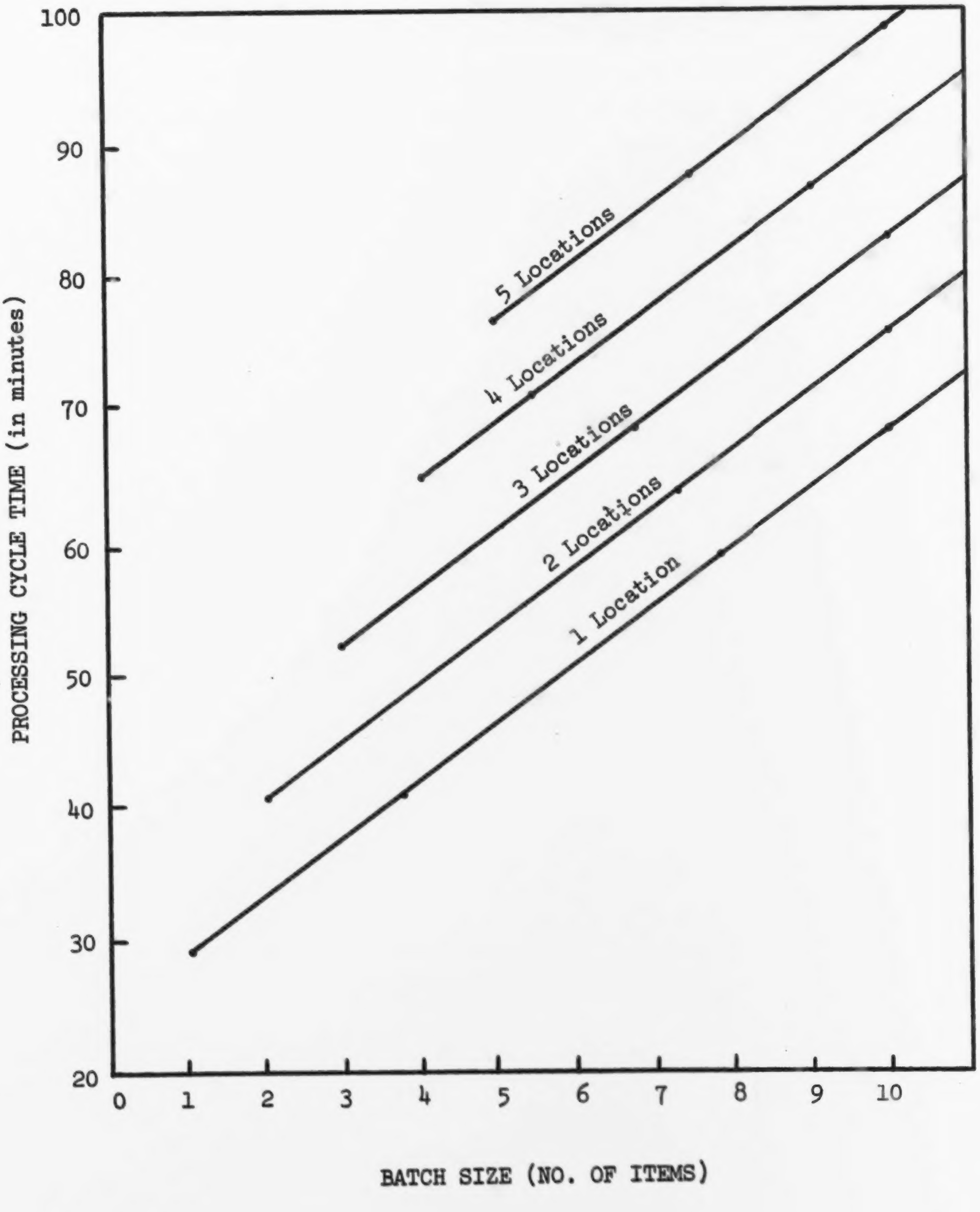
k_1 = 4.48 minutes/item

k_2 = 7.45 minutes/location

These results correspond remarkably well with the analysis of processing effort presented in Figure 18. The regression results are presented in Figure 21. Thus, cycle time is shown as a function of batch size, taking into account the number of locations involved.

FIGURE 21:

RELATIONSHIP OF BATCH SIZE TO PROCESSING CYCLE TIME, BY NUMBER OF LOCATIONS WHERE PAGING WAS DONE



Another issue involved the physical weight of the original materials. During the cycle, a page had to pick up as many as fifteen items in a batch. When paging was done without the aid of a bicycle (as it was on rainy days) there were often too many volumes in a batch to be carried conveniently. For this reason we recorded the weights of a sample of items. The results are given below in Figure 22.

FIGURE 22: PHYSICAL WEIGHTS OF VOLUMES HANDLED DURING EXPERIMENT

Weight of Volume	Number of Items	Per Cent
Less than 1 lb.	8	4.5
1 - 1.99 lbs.	16	9.1
2 - 2.99 lbs.	80	44.9
3 - 3.99 lbs.	38	21.3
4 - 4.99 lbs.	13	7.3
5 lbs. and above	23	12.9
Total	178	100.0

B. NATURE OF DEMAND FOR LDX

This sub-section presents demand-related results of the study. The issue of copy quality is examined in part 1. An abstract of the principal demand characteristics is presented in part 2. An analysis of user response to the experimental system is found in part 3.

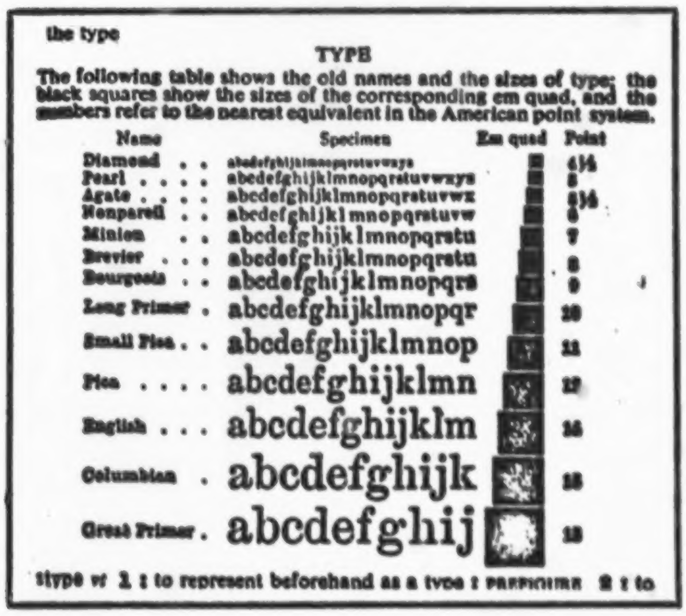
1. Copy Quality. A significant issue in the demand for a facsimile service is the quality of the copy that can be provided. Prior to the beginning of the experiment we had to choose LDX equipment with 135 or 190 LPI (lines per inch) resolution. The 190 line per inch machine would have provided better copy, but at the expense of speed. As a

result of a test in which we examined samples of each resolution, a 135 LPI machine was chosen, on the assumption that it was capable of handling most Interlibrary Loan material.

Our users' responses indicated that the 135 LPI resolution was, for the most part, adequate. Six per cent of the users found the quality unacceptable, and in all of these cases except one the article was in a foreign language.

In order to investigate further the issue of copy quality, we transmitted test copy which had been chosen for its formidable characteristics. We included pages with small type (of the kind appearing in footnotes), mathematical notation, charts and tables, and other potentially difficult elements. The results of these tests were, in general, quite good and indicated that copy quality did not present a problem unless one attempted transmission of pages where type fonts were less than six point. (Figure 23) Several other difficult cases were selected--an engineering drawing and test patterns used by the Library Technology Project. Each of these samples was copied on the 914 Copier prior to transmission. Appendix III includes the original (914 copy) and the LDX copies of the test materials.

FIGURE 23: SAMPLE LDX COPY



the type

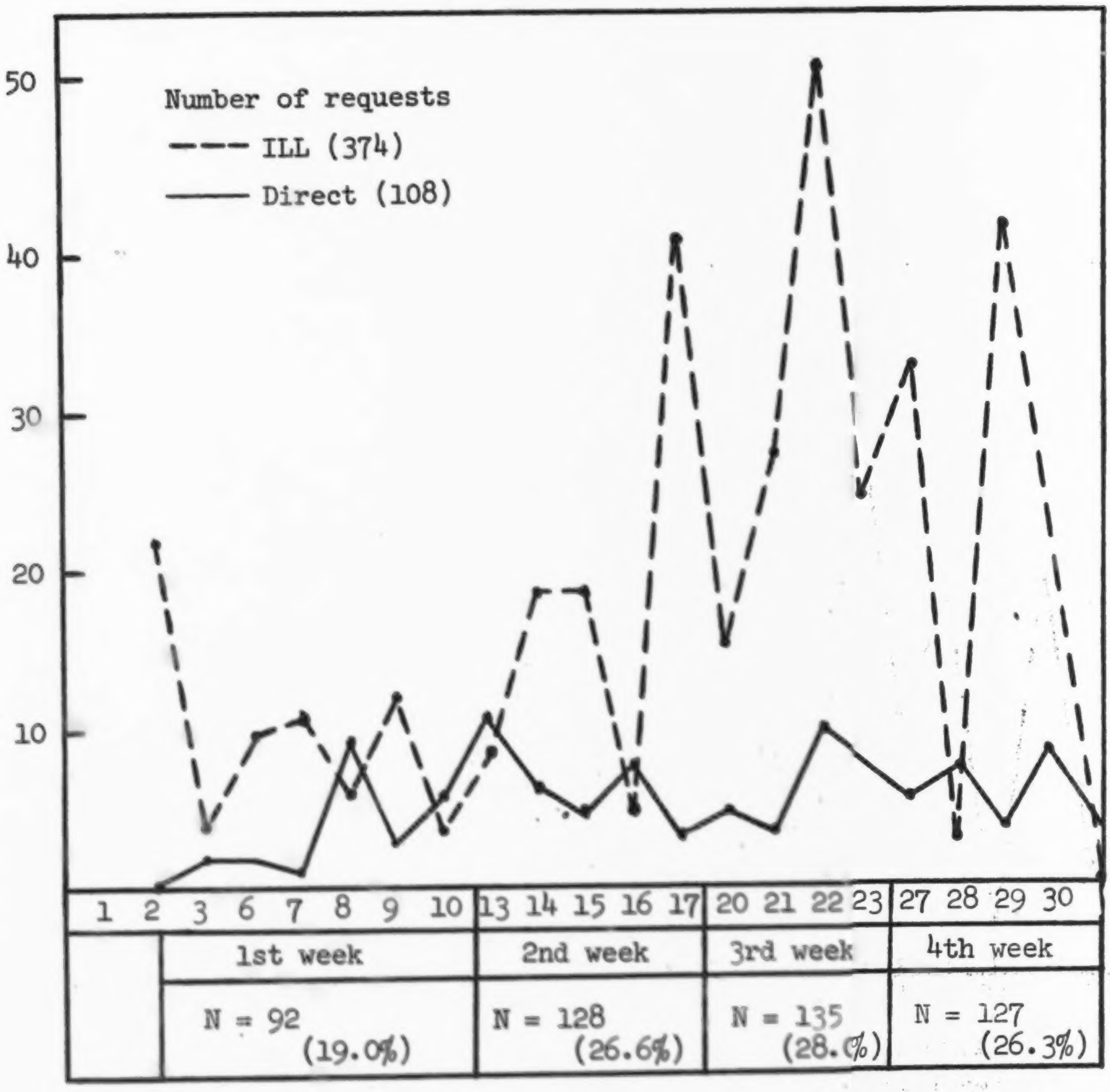
TYPE

The following table shows the old names and the sizes of type; the black squares show the sizes of the corresponding em quad, and the numbers refer to the nearest equivalent in the American point system.

Name	Specimen	Em quad	Point
Diamond . .	abcdefghijklmnopqrstuvwxyz	■	4½
Pearl	abcdefghijklmnopqrstuvwxyz	■	5
Agate	abcdefghijklmnopqrstuvwx	■	5½
Nonpareil . .	abcdefghijklmnopqrstuvw	■	6
Minion . .	abcdefghijklmnopqrstu	■	7
Brevier . . .	abcdefghijklmnopqrstu	■	8
Bourgeois . .	abcdefghijklmnopqrs	■	9
Long Primer .	abcdefghijklmnopqr	■	10
Small Pica . .	abcdefghijklmnop	■	11
Pica	abcdefghijklmn	■	12
English . . .	abcdefghijklm	■	14
Columbian .	abcdefghijk	■	16
Great Primer .	abcdefghij	■	18

type vt 1 : to represent beforehand as a type : PREFIGURE 2 : to

FIGURE 24:
SUMMARY OF DAILY REQUEST VOLUME, BY SOURCE OF REQUEST

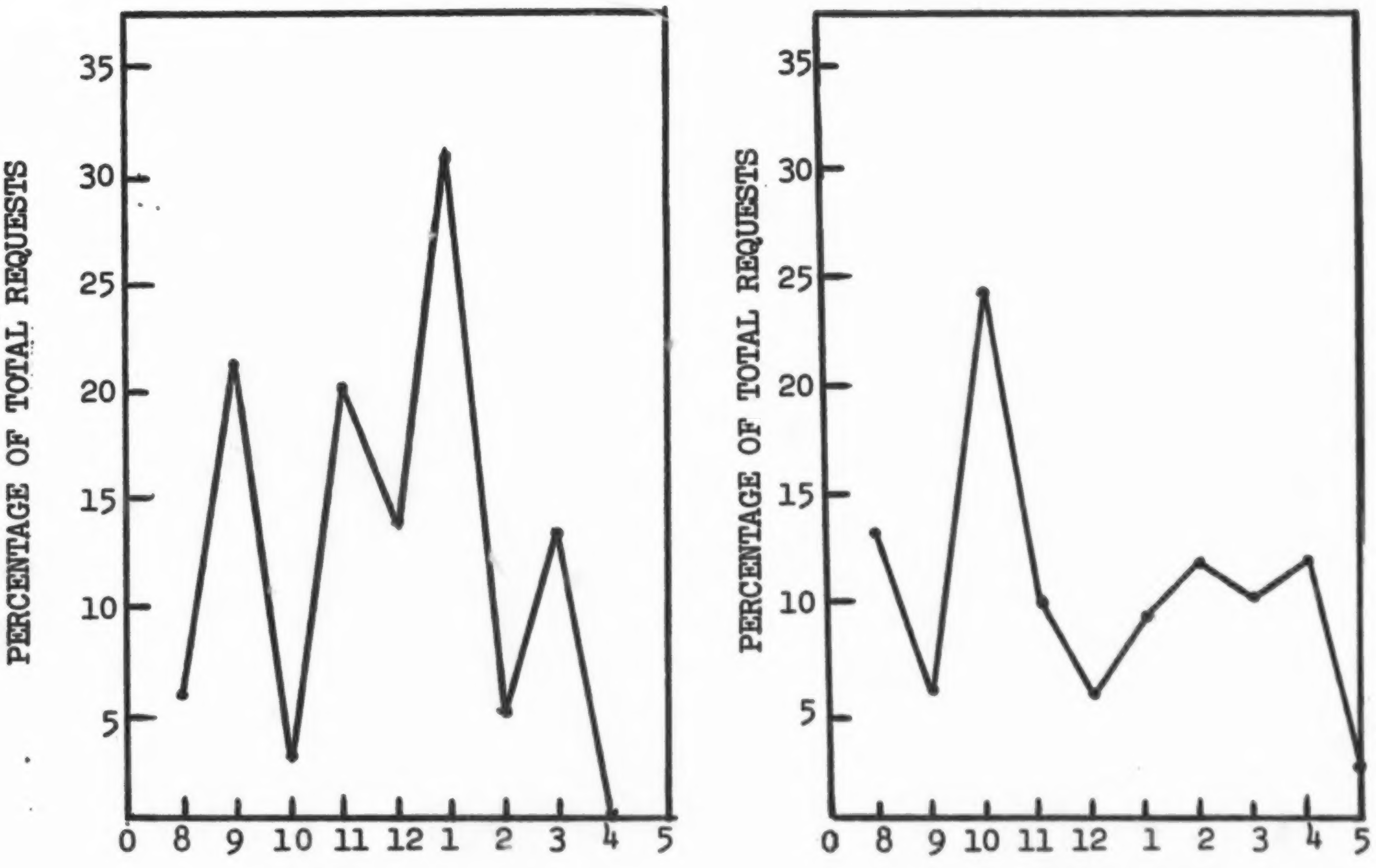


2. Demand Characteristics. During the experiment, requests were accepted from two sources: either through the Davis Interlibrary Loan (ILL) staff or directly from the requestor. The curve representing volume for each source is plotted in Figure 24. From this graph it is obvious that there was a wide range in the daily demand. The minimum number of requests received on any working day was six and the maximum sixty-two. This wide variability would, of course, have important implications for the design of an operational system.

A similar variability was experienced from hour to hour during the working day. This is presented in Figure 25, in terms of the mean percentage of each day's requests received during each hour of operation.

Because ILL requests were batched and received at certain hours of the day (9:00 and 11:00 a.m. and 1:30 and 3:00 p.m.), whereas direct requests were received at any time between 8:00 a.m. and 5:00 p.m., we have plotted separate graphs for ILL and direct requests.

FIGURE 25: DISTRIBUTION OF TOTAL REQUESTS
BY TIME OF RECEIPT DURING DAY



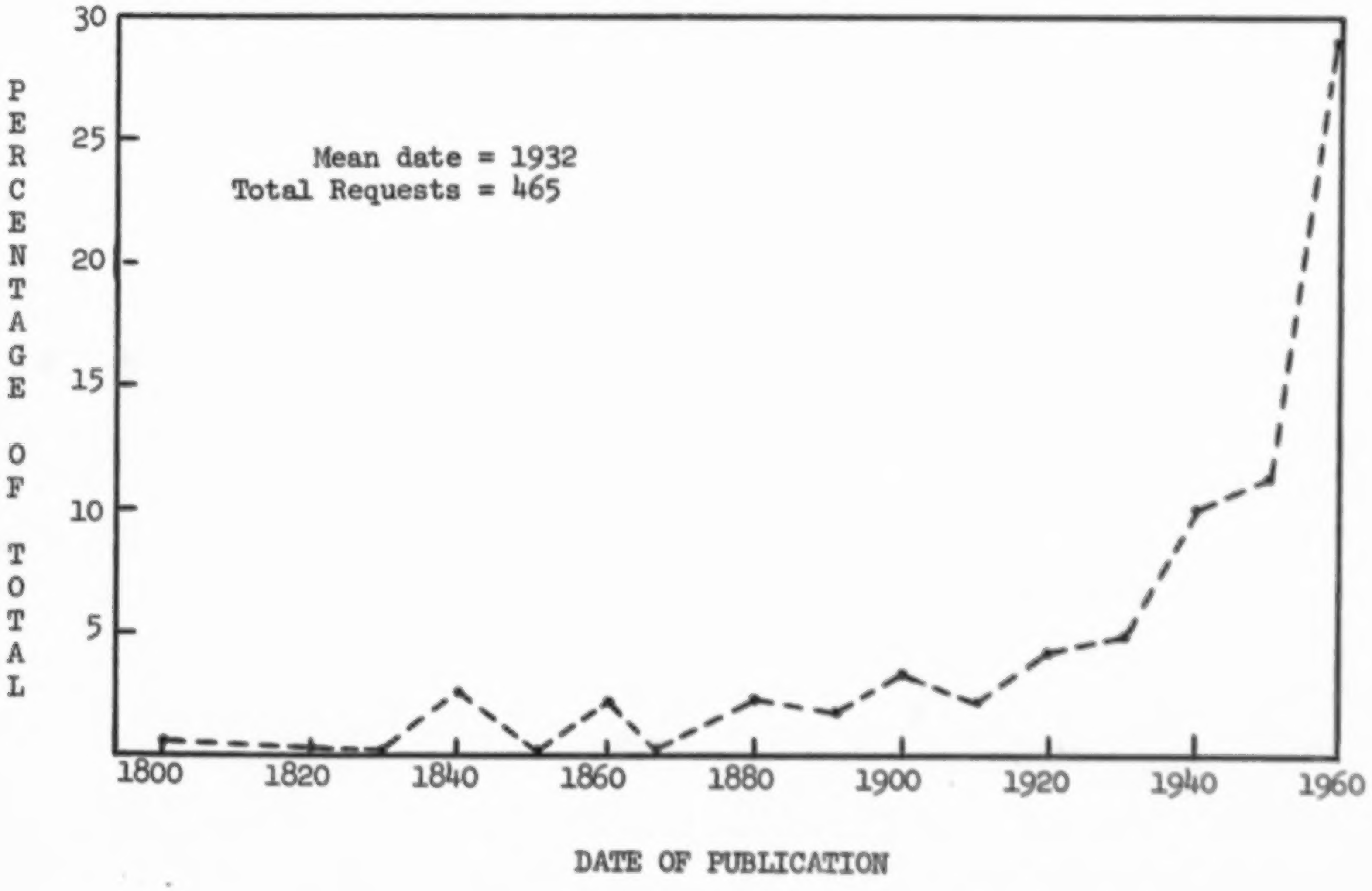
Time of day
RECEIVED FROM
DAVIS ILL (N = 374)

Time of day
RECEIVED DIRECTLY
FROM REQUESTOR (N = 108)

Several other analyses were done with the intention of discerning patterns in demand. In one of these, distribution of requests by users' departments (on the Davis campus) was plotted to determine the causes of variations in use among departments. Our analysis indicated that no correlation existed between the size of the department and the amount of use made by members of the department. Therefore, we concluded that the amount of use is a function of availability of resources. It is worth mentioning here that the user, in making a direct request, was free to request transmission of any title which he thought might be in the Berkeley Library, including those which may have been available on his own campus (i.e., in the Davis Library). At the completion of the experiment, we compiled a list of each of the 334 unique titles requested during the experiment and determined how many of these were available on the Davis campus. The result: approximately 10 per cent of the direct requests could have been serviced from materials on the Davis campus.

We also obtained data on the year in which each requested journal article was published. Figure 26 shows the distribution of requests by decade. As would be expected, the most recent materials had the highest request volume. This distribution can be expected to vary as a function of the materials held in both the receiving and the transmitting libraries.

FIGURE 26:
DISTRIBUTION OF TOTAL REQUESTS BY
DATE OF PUBLICATION



3. User Response to LDX. We wished to ascertain whether or not members of the academic community were interested in having telefacsimile access to library resources. In terms of a one-month operation, it appears that they are unenthusiastic. Their lack of interest was manifest in four ways: (1) Of 1726 academic staff members on the Davis campus, all of whom were sent notices of the availability of LDX, a total of only 123 used the service and of these only 42 took advantage of the opportunity to make direct requests. (2) Pickup delay time (the time between notification to the requestor that his material was ready and the time he picked it up) averaged 8 hours on a 9-hour-day basis and 60 hours on a 24-hour-day basis. The latter time reflects pickup delays extending over weekends.* (3) The questionnaire responses did not indicate a willingness on the part of the users to support a telefacsimile system. Only one-fourth of those who used the system indicated that it would have mattered if the service had not been available. (4) The demand for interlibrary loan was not significantly higher during the experimental period than it was during the preceding and succeeding months.

Each requestor whose material was transmitted via LDX received (by surface transport) a questionnaire card as well as the standard Xerox copy of the requested article. If he submitted several requests at once, only one card was sent to him. The questionnaire was designed to evaluate the response to LDX service on three levels. Each user was requested to indicate: (1) whether or not he was satisfied with the service, including his specific response to service time and copy quality; (2) whether or not he thought telefacsimile transmission of interlibrary loans was worthwhile and should be continued; (3) whether or not he would support and use such a service. A total of 112 cards were returned, providing us with a response representing 52% of all requestors. The results of the tally are summarized in Figure 27.

Of special interest was question 4 which asked the respondent to indicate how much he was willing to pay (per page) for the service. 25.9% of the respondents indicated no willingness to pay for the service. The answers of the 82 people willing to pay are summarized below in Figure 28.

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* Further, this delay was independent of the service time provided.

FIGURE 27: SUMMARY OF QUESTIONNAIRE RESULTS

(N = 112)

Question number	Question on card	Response Yes	Response No	No response
1	Was LDX copy acceptable?	104 (92.9%)	8 (7.1%)	0 (0%)
2	Have you used the material you received?	97 (86.6%)	14 (12.5%)	1 (0.9%)
3	Would it have mattered if you hadn't received the material until now?	29 (25.9%)	82 (73.2%)	1 (0.9%)
4	Would you be willing to pay for the service?	82 (73.2%)	29 (25.9%)	1 (0.9%)
5	Could you charge copies to a research grant?	53 (47.3%)	55 (49.1%)	4 (3.6%)

FIGURE 28: USER INCLINATION TO PAY FOR LDX

Amount willing to pay per page	Number	Per Cent
5¢	3	3.7
10¢	6	7.3
20¢	64	78.0
30¢	1	1.3
40¢	7	8.5
60¢	1	1.2
Total	82	100.0

A three-line space was provided at the bottom of the questionnaire card for the respondent to make comments about the service. We have categorized the comments into the eight types shown in Figure 29. A total of 65 (58%) of the respondents elected to make comments.

FIGURE 29: SUMMARY OF USER COMMENTS

Comments	Number	Per Cent
Service desirable if speed needed	17	26.1
Generally satisfied	13	20.0
Satisfied with service time	2	3.1
Generally neutral comment	5	7.6
Neutral with respect to quality	8	12.4
General dissatisfaction	4	6.2
Dissatisfaction with copy quality	14	21.5
Dissatisfaction with service time	2	3.1
Total responding	65	100.0

Question 3 requested the respondent to indicate whether it would have mattered if he had not had access to telefacsimile service. In order to determine whether those people who responded negatively to the question were, in fact, significantly different from those answering in the affirmative, we calculated the average pickup delay for each group. The difference between the two averages did prove to be significant: those who responded that it did not matter waited, on the average, 7-1/2 hours before picking up their materials; those who responded that it did matter waited only 2-3/4 hours. These results are consistent with the behavior one would expect from the two groups.

The most striking inconsistency in the response pattern is that although three-fourths of the respondents stated that it would not have mattered if they had not received the article until the standard Xerox copy came, the same fraction of the total were willing to pay for the service. The answer to this apparent contradiction was suggested by many comments: a high-speed access method is desirable but it would be used only if materials were needed urgently.

In general, respondents were satisfied with the quality of the copy. This confirms our assumption that 135 line-per-inch resolution is adequate to handle Interlibrary Loan materials.

C. COST OF THE LDX SYSTEM

This sub-section presents detailed information on the cost of LDX. The first part provides a summary of cost of this system. Parts 2, 3, and 4 contain information on the cost of the facsimile equipment, transmission link, and staffing. In each of these sections we have provided equations which we used to calculate the cost of this system.

1. Summary of Costs. In calculating costs we have made several assumptions: (1) that all installation charges would be amortized over a three-year period; (2) that the transmission line would be priced at the commercial rate, derived from interstate broadband rates for a 48 KC channel; and (3) that each LDX Scanner communicates with only one Printer. In Figure 30 we have presented a table of costs calculated for the Berkeley to Davis operation; these are derived from the three equations presented in parts 2, 3, and 4. Figures are shown for varying monthly request volumes at each of three average request sizes. Thus it is useful to show both the cost per page and the cost per transaction. Attention should be called to the fact that the cost of non-serviced requests is allocated to the serviced requests. In the experiment the ratio of serviced to non-serviced requests was 4:1.

Figure 31 shows cost per transaction as a function of system volume (in terms of the number of transactions per month). The three curves represent differing average request sizes of twenty, fifteen and ten pages, respectively.

2. Telefacsimile Equipment. LDX equipment is marketed on a lease basis by the Xerox Corporation, with a minimum charge of $550 per month for each Scanner and $650 per month for each Printer. This base rental includes a footage allowance of 2500 feet per month (2500 copies) for each machine. In addition, it is possible to have each Scanner equipped with an automatic document feeder (ADF). The ADF allows for continuous unattended transmission, and, from our experience, is essential in a large-volume operation. Its cost is $40 per unit per month. In addition to the equipment costs described above, we have estimated that $.003 per page will be spent on LDX supplies, and $.05 per page for

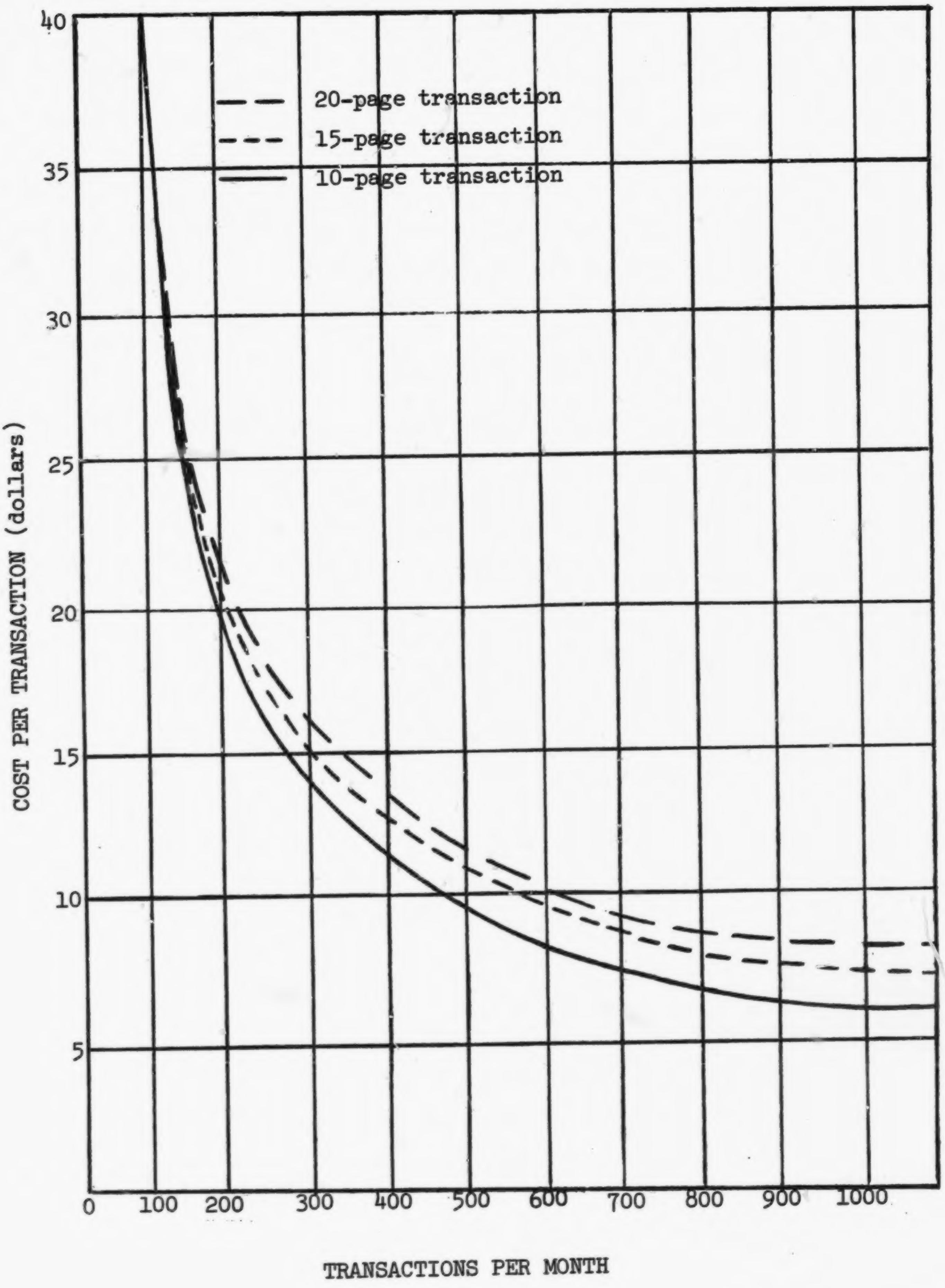
FIGURE 30: SUMMARY OF COSTS, IN TERMS OF SYSTEM VOLUME AND SIZE OF TRANSACTION
(LDX SYSTEM: BERKELEY TO DAVIS)

Monthly Transaction Volume	Average Number of Pages Per Transaction	Total Pages Per Month	Cost Per Month			Total	Cost Per Page	Cost Per Transaction	Staff Cost as Per Cent of Total Cost
			Equipment and Supplies	Line	Staff*				
50	10	500	$1,287	$2,321	$ 89	$3,697	$7.394	$73.94	2.4
	15	750	1,301	2,321	114	3,735	4.980	74.70	3.0
	20	1,000	1,314	2,321	139	3,773	3.773	75.46	3.7
100	10	1,000	1,314	2,321	178	3,812	3.812	38.12	4.7
	15	1,500	1,340	2,321	228	3,889	2.592	38.89	5.9
	20	2,000	1,367	2,321	278	3,965	1.982	39.64	7.0
250	10	2,500	1,393	2,321	444	4,158	1.663	16.63	10.7
	15	3,750	1,522	2,321	569	4,412	1.176	17.64	12.9
	20	5,000	1,651	2,321	694	4,665	0.933	18.66	14.9
500	10	5,000	1,651	2,321	888	4,859	0.972	9.72	18.3
	15	7,500	1,909	2,321	1,138	5,367	0.716	10.74	21.2
	20	10,000	2,166	2,321	1,388	5,874	0.587	11.74	23.6
1000	10	10,000	2,166	2,321	1,775	6,262	0.626	6.26	28.3
	15	15,000	2,556	2,321	2,275	7,652	0.510	7.65	30.0
	20	20,000	3,021	2,321	2,775	8,117	0.406	8.12	34.2

* Staff costs computed on the assumption that transactions (serviced requests) represent 80% of the total request volume.

2

FIGURE 31: COSTS PER TRANSACTION OF EQUIPMENT, TRANSMISSION LINK, AND STAFF AS A FUNCTION OF TRANSMISSION VOLUME (LDX SYSTEM: BERKELEY TO DAVIS)



Xerox 914 copies. The equations we used to calculate equipment costs are given in Figure 32. The equation appears at the top of the table with its parameters defined below it. Opposite each parameter we have listed the value which we used for the cost summary appearing in Section 4.

3. Transmission Link. Any prediction of total cost of a facsimile system is complicated by the fact that transmission costs vary so widely, depending on local factors. Like equipment costs there are two types of charges: recurring charges (usually expressed in terms of dollars per month) and one-time installation charges (which are amortized over a given period). In calculating transmission link charges we have used the commercial interstate rates for a 48 KC channel (Series 8000 service, formerly TELPAK "A"). The rates for this service are as follows:

Mileage	Cost per mile per month
0-250	$15.00
251-500	$10.50
501 and up	$ 7.50

In order to be able to transmit facsimile information an interface unit (called a "data set" or "modem") is required at each station. The cost of each unit is approximately $450 per month. Installation costs are extremely variable; for this reason we have not attempted to estimate them. The equation for transmission link monthly cost is presented in Figure 33.

4. Staff. Staff costs fluctuate considerably depending upon the method used to provide service. If requested items are to be obtained immediately from the shelves, Xeroxed, and transmitted promptly, the elapsed time for the completion of transactions will be minimized; but staffing costs will be greater than with a slower, but more economical, method in which requests are batched. Basing calculations on Figure 18, we have separated staff time per item into two components: processing time which is dependent upon an individual item (time spent in look-up, paging, etc.) and processing time which is dependent upon the number of pages handled (time spent in copying, transmission, etc.). Given this particular system configuration, the time per transaction is .31 hours and the time per page is .04 hours. The staff-time equation is shown in Figure 34.

FIGURE 32:
TELEFACSIMILE EQUIPMENT COST
(EXCLUDING TRANSMISSION LINK)

Total monthly equipment cost = C_{equip} =

$$(C_{scan} \cdot Q_{scan} + C_{prnt} \cdot Q_{prnt} + C_{adf} \cdot Q_{adf}) + (I_{scan} \cdot Q_{scan} + I_{prnt} \cdot Q_{prnt})/R + V_{tr}\, A(C_{page} + C_{suppl}) + V_{xtra} \cdot C_{xtra}$$

PARAMETER	EXPERIMENTAL VALUE
C_{scan} = monthly charge, each scanner	550
Q_{scan} = number of scanners	1
C_{prnt} = monthly charge, each printer	650
Q_{prnt} = number of printers (where $Q_{scan} = Q_{prnt}$)	1
C_{adf} = monthly charge, each ADF	40
Q_{adf} = number of automatic document feeders	1
I_{scan} = installation charge, each scanner	300
I_{prnt} = installation charge, each printer	450
R = amortization period, no. of months	36
C_{page} = unit cost/914 page	.05
V_{tr} = number of transactions/month	variable
A = average number of pages/transaction	variable
C_{suppl} = monthly supply cost/page	.003
V_{xtra} = number of pages in excess of $2500 \cdot Q_{scan}$	variable

FIGURE 32 (Cont.):
TELEFACSIMILE EQUIPMENT COST
(EXCLUDING TRANSMISSION LINK)

PARAMETER	EXPERIMENTAL VALUE
C_{xtra} = combined printer and scanner cost per page of excess copy	
If Excess pages (V_{xtra}) = 0 - 10,000	.05
10,001 - 50,000	.04
50,001 - 100,000	.03
100,001 - 175,000	.025
175,001 - 1,000,000	.020
1,000,001	.015

FIGURE 33: TRANSMISSION LINK COST

Total monthly transmission cost = C_{trans} =

$$C_m \cdot M + C_{ds} \cdot Q_{ds} + (I_{line} + I_{ds} \cdot Q_{ds})/R$$

PARAMETER	EXPERIMENTAL VALUE
C_m = cost/mile/month (in \$) *	
Mileage (M)	
1 - 250	15.00
251 - 500	10.50
500 and above	7.50
M = total system mileage (via pricing route)	90
C_{ds} = monthly charge for each data set (\$)	450
Q_{ds} = number of interface units (data sets req'd.)	2
I_{line} = total system microwave/cable installation charge (\$)	1200
I_{ds} = installation charge, each data set (\$)	675
R = amortization period, no. of months	36

*Based on Series 8,000 broadband service (interstate rate)

FIGURE 34: STAFF COST

Total monthly staff cost = C_{staff} = $(T_{item} \cdot V_{tr} + T_{page} \cdot V_{tr} \cdot A) \cdot C_{rate}$	
PARAMETER	EXPERIMENTAL VALUE
T_{item} = average processing time/transaction	.31
V_{tr} = number of transactions/month	variable
T_{page} = average processing time/page	.04
A = average number pages/transaction	variable
C_{rate} = average hourly cost of staff time	2.50

V. IMPLICATIONS OF THE STUDY

This section extracts information from the experiment which is useful in formulating generalizations applicable to other library systems. In Section A we have listed what we consider to be the most important characteristics of telefacsimile systems. Comparisons of telefacsimile with two other types of distribution systems are presented in Section B.

A. TELEFACSIMILE SYSTEM CHARACTERISTICS

The design of a telefacsimile system is subject to both inherent and imposed constraints. Inherent constraints are those which are not subject to change by executive decision. These constraints are the geographic distribution of demand for service, the capacity of the equipment and personnel, and the time variability of demand upon the system. Imposed constraints, by contrast, are those which can be changed by executive decision. These are the definition of service and the total cost to be incurred by the system. Let us consider the impact of these individual constraints.

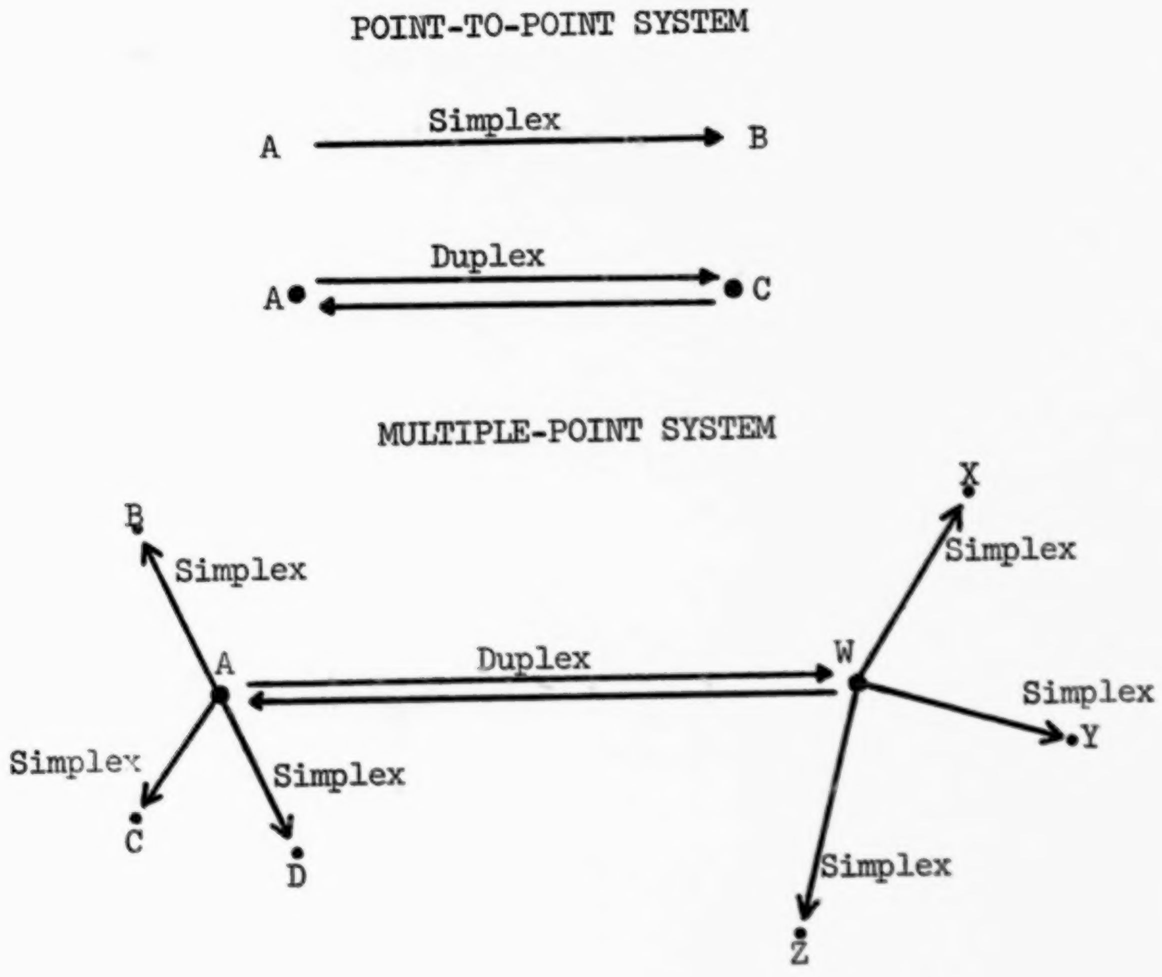
1. Geography of Demand. The location of service facilities within a telefacsimile system will to a large extent be determined by the geographical distribution of demand within the service region. The receivers should be placed in locations which minimize the time and effort required for requestors to obtain their materials; the transmitters should be located close to the source of the materials. The more transmitters and receivers there are, the greater the system cost. Selection of the proper number is highly dependent upon the individual situation and is outside the scope of the study.

Once the general locations have been defined, it is necessary to select specific sites for the equipment. Time and effort are partially dependent upon the transport of the material to the transmission facility. If there is only one possible location for the material, it is not difficult to compute the amount of delay and cost that will be required to transport the materials. In most situations, however, there are multiple locations from which materials will be drawn, each with its own frequency of withdrawal of materials and time to transport them to the transmitter site. In such a situation, it is difficult to compute precisely the time delay and cost in this portion of the operation because of the many combinations of batch sizes and locations that are possible. Fortunately, our analyses indicate that a precise computation is not necessary. Accuracy sufficient for the design of a system can be obtained by estimating both the demand on the individual components of the library and the travel time from the library to the transmission facility, and using these estimates to compute delay and transport effort in the processing of a batch of requests.

The physical plant of a source library generally will consist of a centrally located main facility with one or more branch libraries. For maximum efficiency the transmitting station should be located in the unit which experiences the greatest request volume. In most cases, this would mean locating the transmitter in the central stack area. With this arrangement, items removed from the shelves of the central stacks would not have to be charged out, thus eliminating a processing step. In other branches, a simplified charging procedure would be desirable.

2. Equipment and Personnel. The organization of an operating system is subject both to equipment and to personnel constraints. With respect to equipment, two different system configurations exist: point-to-point and multiple-point. Figure 35 illustrates these configurations. In point-to-point organization, each equipment facility communicates with one other facility. The communication link can be equipped to handle transmission in either one or both directions between the two points. In a one-way (simplex) operation the equipment consists of a transmitter at one location and a receiver at the other. For operation in both directions (duplex) each station must be equipped with a transmitter and a receiver (which may be the same unit). In multiple-point organization, switches at each transmitting station allow it to transmit to any one of the several receivers to which it is connected. Alternatively, several different transmitters may transmit, one at a time, to a single receiver. As in the point-to-point system, it is also possible to operate in simplex or duplex mode. For duplex mode there must, of

FIGURE 35: TRANSMISSION SYSTEM CONFIGURATIONS


POINT-TO-POINT SYSTEM
A
Simplex
B
Duplex
A
C
MULTIPLE-POINT SYSTEM
B
Simplex
A
Duplex
W
X
Simplex
Simplex
Y
Simplex
Simplex
C
D
Simplex
Z

course, be a transmitter and a receiver at each station, and a communication switching system capable of connecting the desired units to each other upon demand.

In this study we have utilized the least sophisticated of all configurations, a single-point simplex system. Much of the behavior of multiple-point configurations can be inferred from the results of this study. However, the queueing characteristics must be computed for the total use of joint facilities, and the costs must be computed since the communication system is changed.

With respect to system throughput, the effective rate is constrained by personnel and equipment. Certain of the activities are purely manual and are thus constrained solely by the production rates of the personnel. In our experiment the effective rates to perform these steps were the following:

Item processing	
Receive request.	2.0 minutes
Look up in catalog.	1.4 minutes
Page and charge.	4.8 minutes
Other processing	2.2 minutes
Subtotal	10.4 minutes
Transfers	2.7 minutes
Total	13.1 minutes

The transmission activity is constrained by both equipment and personnel. Thus, the equipment has a maximum transmission rate which determines the minimum transmission time of a request and also the minimum delay time for requests waiting for transmission. However, the effective capacity of the equipment is not identical to the transmission rate, because there are periods during which no transmission takes place. Such periods are caused by equipment or line failure, personnel delays in supplying material to the equipment, or a low volume of requests requiring transmission. If we exclude low demand periods and periods of equipment failure attributable to experimental conditions, we can estimate the effect of normal equipment and personnel constraints on the transmission capacity. Thus in the experiment, the maximum transmission rate of the LDX equipment was 1.75 pages per minute (135 LPI, 48 KC), while the computed effective rate was 79 pages per working hour, which is 75% of the machine's stated maximum transmission rate.

Even though the effective rates of individual installations will vary, these estimates serve as useful bench mark figures for planning a new system. They can be used to estimate the service time and effective production capacity of a given configuration of equipment and personnel. Of course the variability in demand for service can affect these estimates significantly. The effect of this variability is considered next.

3. Time Variability of Demand. The fluctuation of demand on the system is an important inherent constraint on the performance of the system. If the request volume exceeds the maximum production rates of

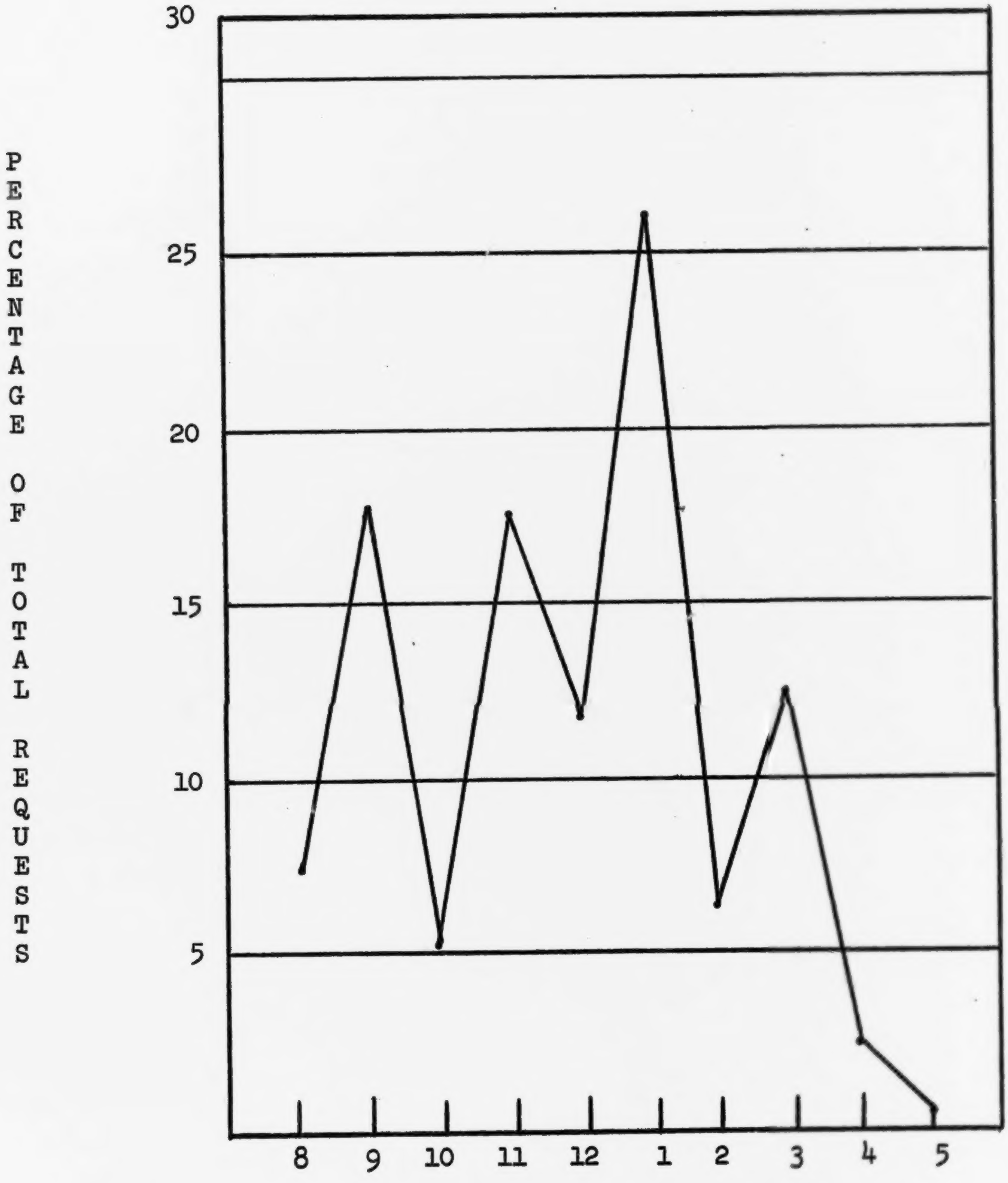
the equipment and personnel, a backlog develops. It is clear from the outline of the service times in various parts of the system that waiting lines did, in fact, develop at each processing step during the experiment. The main reason for the development of these waiting lines is that the demand on the system was not uniform. For example, a waiting line developed at the transmission equipment, even though the total volume of requests over the period of the experiment represented less than 1/3 of the maximum transmission capacity of the equipment. In designing a telefacsimile system to meet required service times, therefore, it is very important to estimate carefully this variation in demand over time in order to be able to predict the amount of backlog and thus the delay that will develop in the processing operations.

Although the variability in demand rate during the day is important to the calculation of the time required to service a request, it is very difficult to predict precisely what this demand curve will look like. However, a general prediction appears feasible. It is our experience that there is a pattern in the requests placed directly and in those received through ILL; that is, we experienced a peak at approximately 10:00 a.m. for the former and at 12:00 noon for the latter. This pattern appears to be an appropriate basis upon which to make a prediction of the demand profile that would obtain in most telefacsimile systems since it is similar to the demand patterns of many library circulation systems.

Figure 36 shows the demand pattern we experienced. This is a composite of direct and ILL requests. This delay time can be used to compute the amount of delay time in the transmission process. First, the average transmission delay time must be estimated for various levels of daily demand. Figure 37 shows the pattern of cumulative arrival of requests during the day for six levels of daily demand: 7, 17, 27, 37, 47 and 62 requests per day. For each of these groups an average transmission delay per request can be computed by the use of the effective capacity estimate obtained from Figure 20. Figure 38 shows the computation of average delay for each of the demand levels given the demand pattern shown in Figure 36. No computation is included for the group

FIGURE 36:

HOURLY DEMAND PROFILE



Time of Day

(Total Number of Requests = 483)

FIGURE 37:
CUMULATIVE ARRIVAL PATTERNS DURING THE DAY
SHOWN FOR SIX LEVELS OF DEMAND

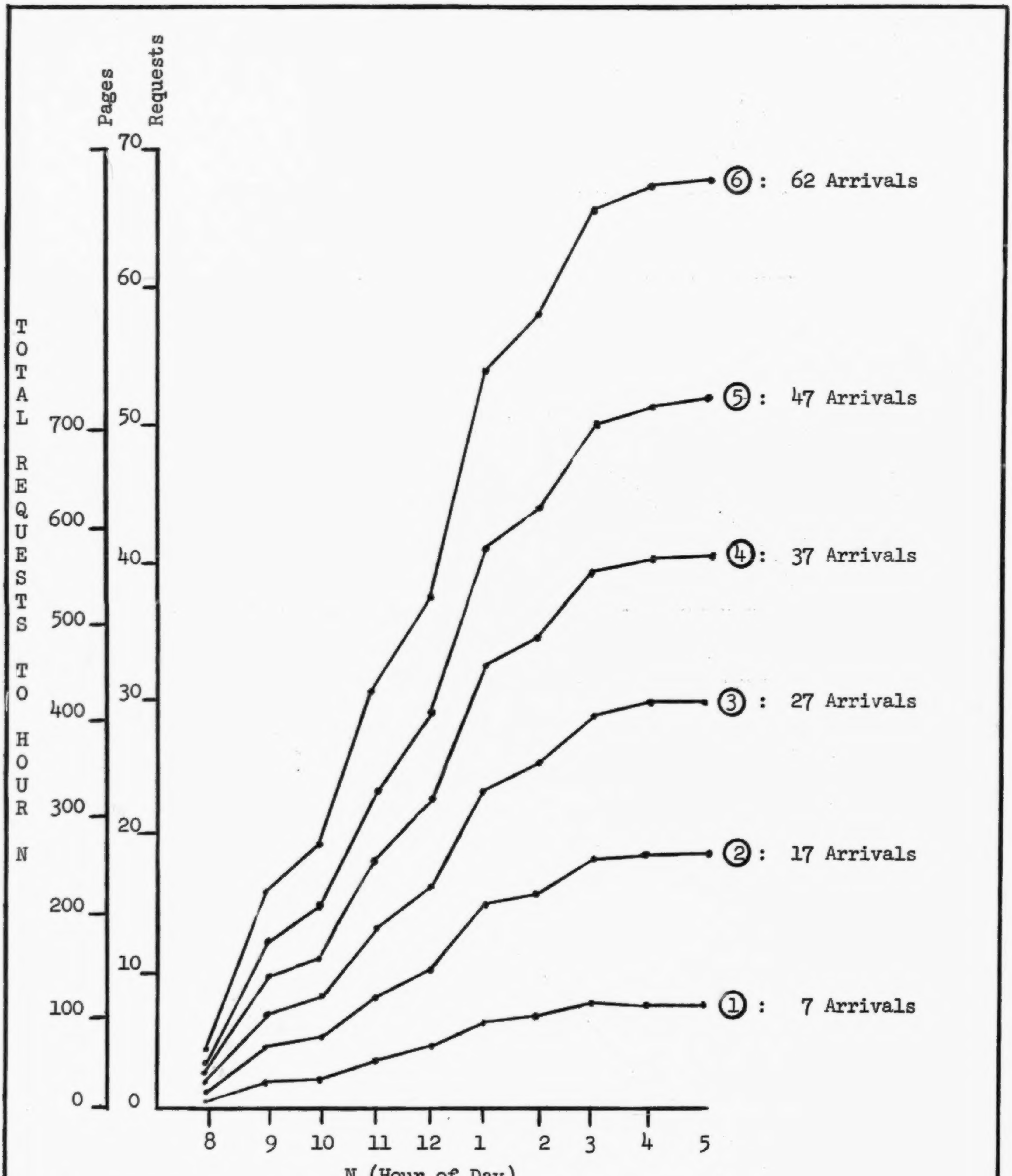


FIGURE 38:
ESTIMATION OF AVERAGE DELAY TIME
BASED ON HOURLY DEMAND PROFILE

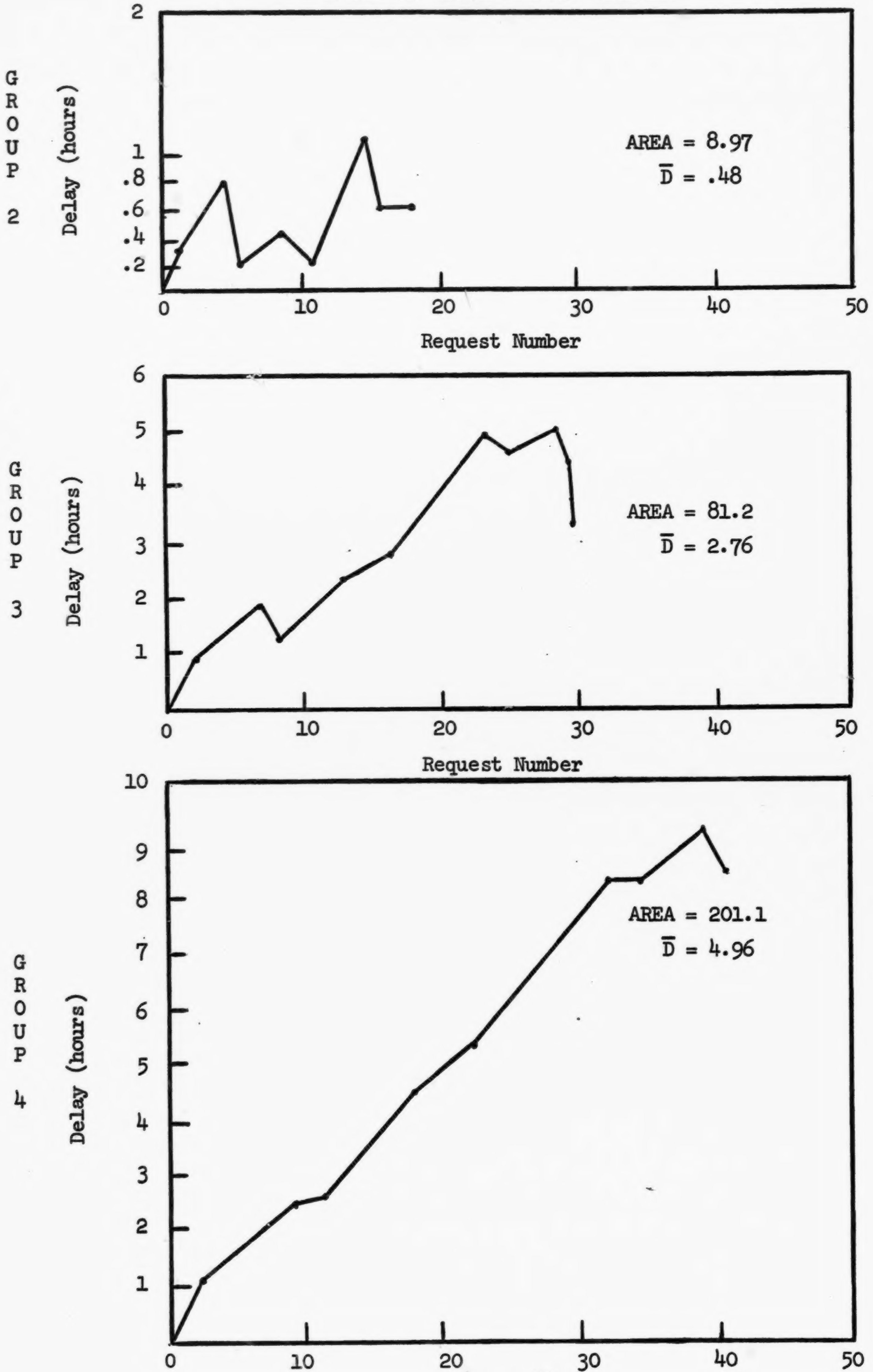


FIGURE 38: (Cont.)

DELAY VS. REQUEST NUMBER

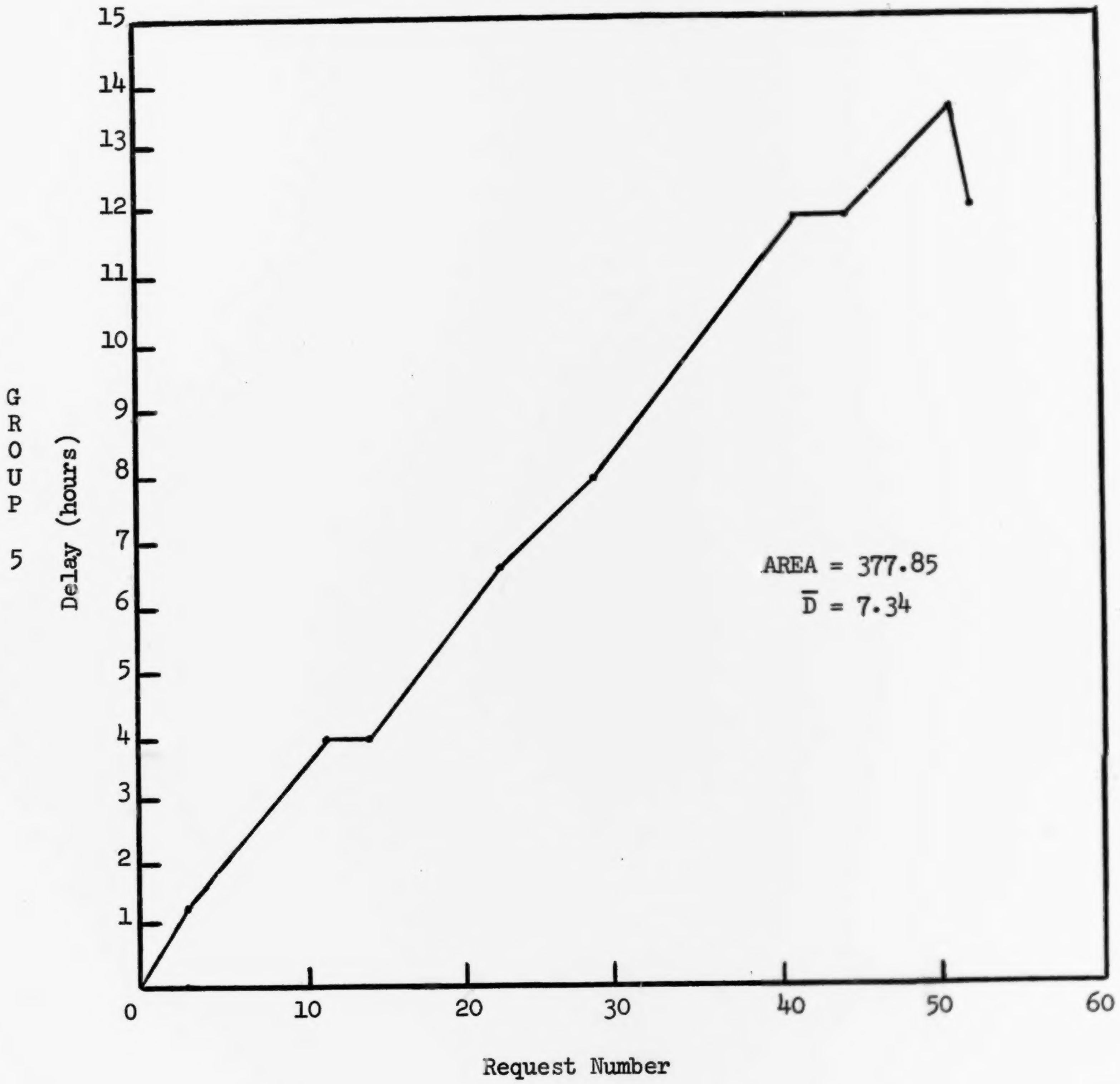
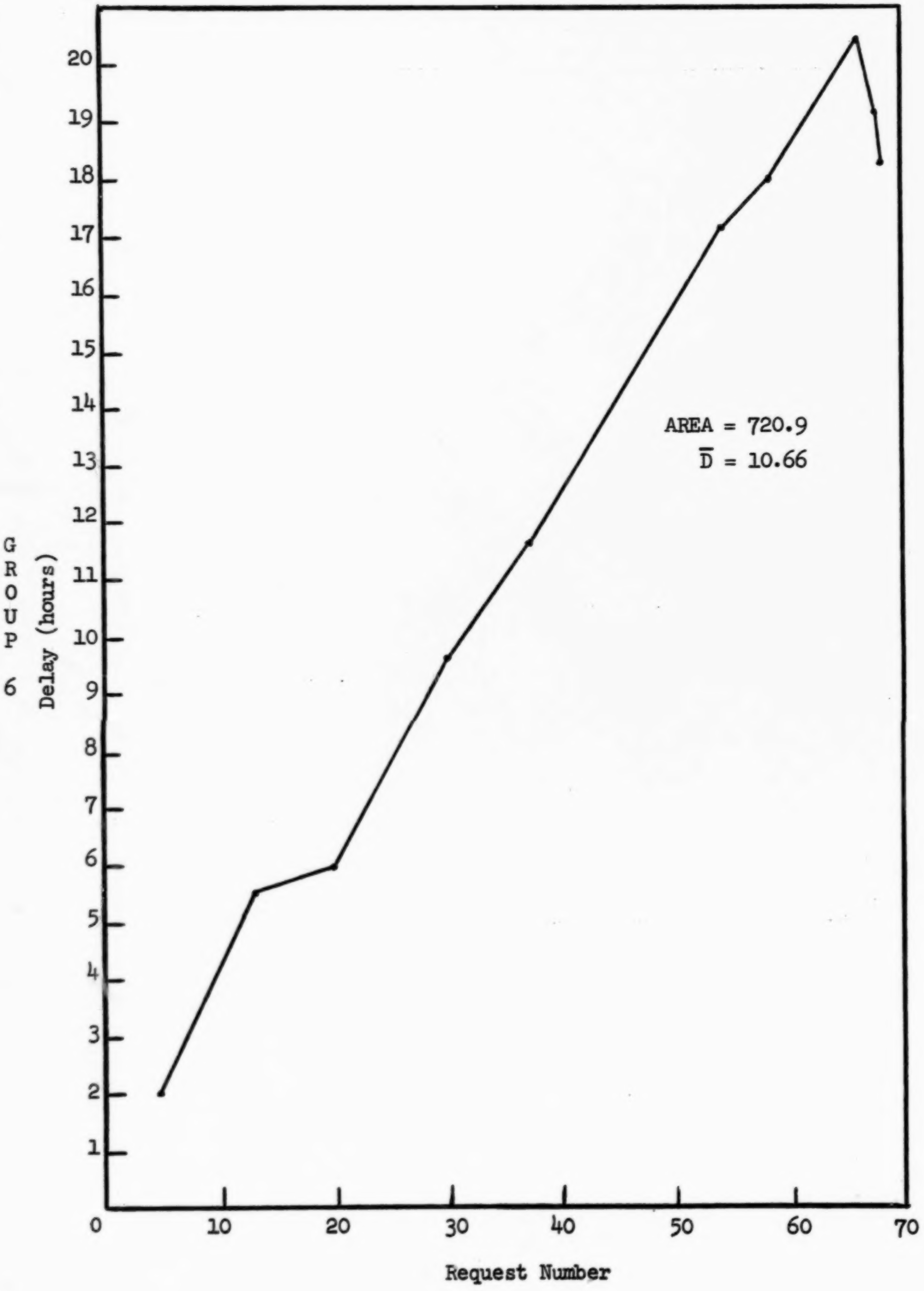


FIGURE 38: (Cont.)
DELAY VS. REQUEST NUMBER



containing seven requests since no delay is encountered. For each group the delay encountered by each arriving request is plotted. From the total delay (the area under the curve) the average delay for the group is computed.

The next variation in demand which must be included is the variation from day to day. This is accomplished by estimating the number of days which will fall in the various size groups: 1-10, 11-20, 21-30, and so forth. Figure 39 gives the distribution of daily demand for these groups. The average delay time can then be computed from the delays for each group. As an example, this computation for our experiment is shown in Figure 40. It provides an estimated average delay of 4.4 hours whereas the measured average delay was 4.2 hours. From this, it appears that this approach provides a reasonable method of estimating the transmission delay time that will be encountered. As these estimates show, the delay is extremely sensitive to the days of very high demand. Thus the estimate of the number of these days is more critical to the estimate of delay than is the estimate of the rest of the distribution.

There are, of course, other points of delay in the system. However, they are not as large and are easily estimated from the information given in Section IV.

4. Service Objectives. The determination of service objective is perhaps the most important step in the design of a telefacsimile system. There appear to be three major objectives from which one can choose. These are: (1) to minimize average service time; (2) to minimize average variation in service time; and (3) to provide service times which are responsive to the varying time requirements of individual users.

Each of these service objectives implies a different priority structure for items awaiting transmission. Because processing time is a function of the length of the item to be transmitted, minimization of mean service time implies a "shortest-in, first-out" structure (that is, items are transmitted in order of their length, the shortest being transmitted first); minimization of variation implies a "longest-in, first-out" structure (items are transmitted in the order of their length, the longest being first); and a system responsive to individual needs implies transmitting

FIGURE 39:

DISTRIBUTION OF DAILY DEMAND

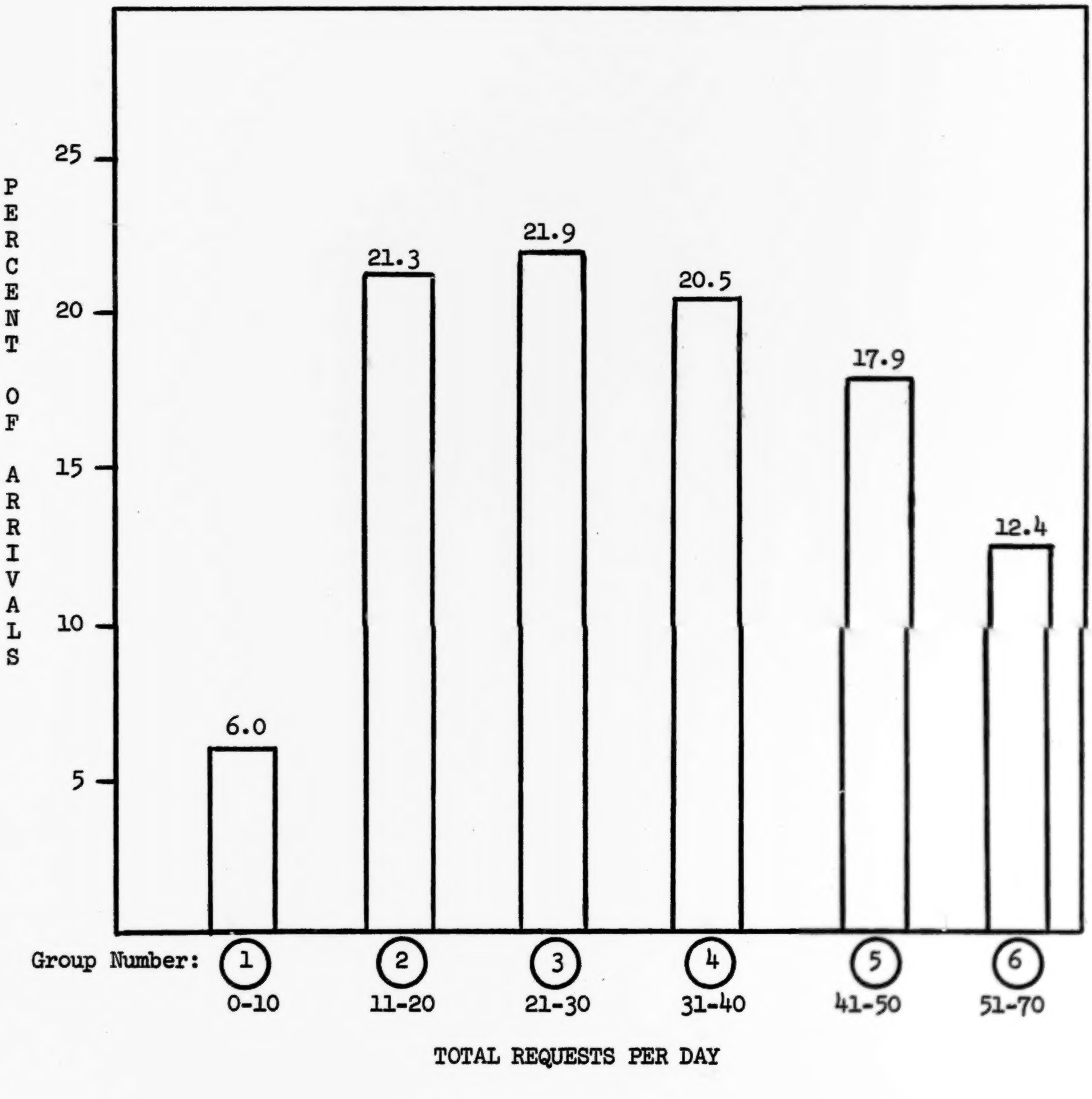


FIGURE 40:
CALCULATION OF AVERAGE DELAY, GIVEN THE DISTRIBUTION OF DAILY DEMAND

Item Average Delay	
Group	$\overline{D}$
1	0 hours
2	.48 "
3	2.76 "
4	4.96 "
5	7.34 "
6	10.66 "

Total Weighted Average Delay

$$\overline{D} = 0 + .48(.213) + (2.76)(.219) + 4.96(.205) + 7.34(.179) + 10.66(.124)$$
$$= .17 + .604 + 1.01 + 1.31 + 1.32$$
$$= \underline{4.41 \text{ hours}}$$

items in the order of the urgency of the need for them, the most urgently needed being sent first.

We have provided an example to illustrate the differences between the average service times and average variation in service time among the "shortest-in, first-out", "longest-in, first-out", and a random priority structure (such as, "first-in, first-out"). If we have six items to be transmitted, which will require 10, 20, 30, 40, 50, and 60 minutes to transmit respectively, we can calculate the delay time for each item (calculated on the basis that its delay time is the sum of its transmission time plus the transmission times of all items preceding it in the queue), average delay time, variation of each individual delay time from the mean, and the average of the variations. These are presented below (Figure 41) for each of the three strategies.

As can be seen from the table, average service time can be minimized by establishing a priority structure in which shorter items are transmitted first. However, the use of this strategy results in a greater average variation than would be obtained using a "longest-in, first-out" technique. Alternatively, if the objective were to minimize average variation (without introducing unnecessary delay) using "longest-in, first-out", one must sacrifice the minimization of average delay time. It should be noted that although "longest-in, first-out" appears counter-intuitive, it is the appropriate strategy due to the assumption that the items arrived at the same time. Where this is not the case it appears that a computational search must be made to select the correct item.

It is also possible to obtain other strategies, whether by choosing a mixture of the three objectives defined, or by having special conditions which apply to the processing. A common strategy which must be considered is that of providing processing in the order of receipt ("first-in, first-out"). Under what conditions would this strategy be "best"? First, if all requests take the same processing time, then this strategy will be best in the sense that it will minimize both average service time and its variance. Second, this strategy will be best in those situations where the attempt to determine the service time requirements of

FIGURE 41: CALCULATION OF AVERAGE DELAY TIME AND AVERAGE VARIATION FOR THREE TRANSMISSION STRATEGIES

Time Required to Transmit Item:
A = 10 minutes D = 40 minutes
B = 20 " E = 50 "
C = 30 " F = 60 "

Transmission Sequence	Strategy Used in Transmission								
	Shortest-in, First-out			Longest-in, First-out			First-in, First-out		
	Item Transmitted	Delay Time	Variation from Ave. Delay	Item Transmitted	Delay Time	Variation from Ave. Delay	Item Transmitted	Delay Time	Variation from Ave. Delay
1	A	10	83	F	60	92	B	20	108
2	B	30	63	E	110	42	F	80	48
3	C	60	33	D	150	2	E	130	2
4	D	100	7	C	180	28	C	160	32
5	E	150	57	B	200	48	A	170	42
6	F	210	117	A	210	58	D	210	82
Total		560	360		920	270		770	314
Average Delay Time		93	---		152	---		128	---
Average Variation		---	60		---	45		---	52

the individual requests would introduce greater delay than could be overcome by reorganizing the processing sequence.

It seems that waiting lines commonly meet one of the conditions under which "first-in, first-out" is most appropriate, eg., lines at a ticket window or a teller's window. There are situations where these conditions do not apply however, and the strategy employed in certain of these is instructive. Consider the self-service market with multiple checkout stations. Since the checkout processing time is a function of the number of items purchased, this time can be readily estimated. Often, one of the checkout stations will be allocated to customers with a small number of items. This appears to be an application of a "fairness" objective. Under this objective, people whose service will cause little delay to others should have to suffer a little less delay than someone whose service will cause greater delay to others.

There is a direct application of this fairness criterion to the telefacsimile transmission queue where items arrive at the transmission facility in batches. All items in the batch would be transmitted before transmission of the next batch began. Thus, for example, if a given batch required two hours to transmit, no item would have a transmission delay time greater than two hours, even though the longest item, which may have been the first request received, is the last item in the batch to be transmitted.

To this point, we have discussed the various approaches with the implicit assumption that the measurement of service is the same for all transactions. By specifying an equal measurement of service time for all requests, the assumption, in effect, is that the material is needed at the time the request is placed. Yet it is important to question whether providing the material before the requestor needs it is of any value. One of the significant implications of our study is derived from the average delay of seven and a half working hours from the time the requestor is notified that the material is available to the time he picks it up. This delay indicates that, in general, requestors do not feel the need of obtaining the material as soon as it is available. Further, the requestor's delay in picking up his material was less for those who responded on the return form that early arrival was important. In recognition of this, an alternative service objective would be to minimize the amount of variation between the time specified by the requestor and the time the material is actually delivered.

We refer to a system operation with this objective as a variable response system. In this system the appropriate strategy is to select material for transmission on the basis of how soon the items are to be delivered. Although we did not use this approach in the experiment, this strategy appears to be most appropriate for the operation of a facsimile transmission system. Because a significant portion of the people using Interlibrary Loan at present are not particularly interested in delivery within one or two hours (even though they may very much desire delivery within the same day), it is likely that this strategy would improve performance from the requestor's viewpoint.

In measuring the performance of a system, only delay beyond the requested delivery time would be counted. No credit accrues to the system for delivery of material before the requested time. A well-designed system would be capable of processing the bulk of the requests within the requested time limits. This strategy provides a direct reading of the desires of the users of the system, and orders its processing accordingly. This information would give a continuing indication of the demand satisfied by the telefacsimile system which is not capable of being satisfied by alternative transport systems.

5. System Cost. In general, the cost of a telefacsimile system is a function of the cost of installing it, the distance and period of time over which it operates, the number of requests, the number of pages transmitted, and the service time. The cost of installing the facsimile transmission system varies with the type of system to be installed and the amount of telefacsimile experience a particular institution has had prior to installation. Any institution should anticipate at least $10,000 in installation costs, since at least six months of man-time will be required for the development of procedures for system operation, the training of personnel to carry out the operation, and the monitoring of the initial operation to ensure proper performance. In addition,

some system reorganization will no doubt be required after the first few months of operation in order to make it conform more closely to the system's objectives. These installation costs can, of course, be amortized over the period of the operation. The cost of the communication link is a function of the time and distance over which it operates. The cost for leased-line transmission is approximately $15 per mile per month. The other components of cost which are dependent on time are the facsimile equipment rental and the cost of the personnel who must be committed to the system regardless of the volume of materials processed. Because of the monitoring requirements of the equipment, the operator of the transmitter and the operator of the receiver must be committed to the system during all hours of its operation. Therefore, the expense of these personnel can be considered as a direct function of the period of time over which the system operates.

Certain other costs are a function of the number of requests. Variable personnel costs are those for the personnel who perform all the processing steps from the initial acceptance of the request through the delivery of the materials to the transmission facility. The personnel cost associated with accepting the request, looking up the material in the catalog and paging the material in the library can be considered variable if the personnel performing this work are able to perform alternative work when the system is not in operation, or during periods of low demand. If this is not the case, then the cost of personnel assigned to this portion of the system are also a function of the period over which the system operates. Although it might appear that the volumes of serviced and non-serviced items would affect system costs, the difference is marginal and can be ignored. (The service time provided by the system, however, is sensitive to the ratio of serviced and non-serviced items.) The rental cost of the equipment is a function of the number of pages transmitted, since the rental cost includes both a period charge and a charge that varies with the number of transmissions. Figure 31 shows the relationship between cost of the transmission equipment and the number of pages transmitted.

Finally, both the service time and the cost of the requests are affected by the total volume since it is possible to reduce service time by providing excess capacity in various portions of the system. Because there is variable demand in the system, the larger the capacity relative to demand, the more frequently will it be possible to process material without incurring backlogs in the various processing steps. Larger capacity, therefore, results in service times that are shorter than they would be in a system of lower capacity. Providing this additional capacity, of course, costs additional money. From the demand estimated for the system, the delay times and the cost per request can be estimated from the information given in Figures 14, 31, and 36-40.

B. COMPARISON OF TELEFACSIMILE TO ALTERNATIVES

A library provides its users with two kinds of access to resources: direct access to materials contained within its collection, and indirect access to materials which must be obtained elsewhere. Because nearly all libraries utilize both methods to service requests, the central problem is to determine whether certain materials should be added to the collection in advance of demand or whether they should be obtained indirectly at the time requests are placed. The most critical elements in deciding between these two alternatives are: frequency of use of the materials, their cost, and the delay time a user is expected to encounter before receipt of requested materials.

It is generally assumed that the requestor will first attempt direct access and, if he fails to find the item in the collection, he will use indirect access. We have defined three types of indirect access: standard interlibrary loan, telefacsimile, and demand delivery via modified surface transport. Demand delivery would include use of special couriers who deliver materials via auto, bus, rail, or plane. One should note, however, that telefacsimile is the only method of indirect access which can provide service which is approximately equivalent in speed to direct on-site access to library resources.

Recall that in a variable-response, indirect access system the requestor specifies the time by which he wishes to receive his material, if it is to be of most value to him. The library's objective is to place the materials in his hands at that specified time. Only those requests which are needed sooner than they can be provided by less expensive methods should be handled by a faster method--either telefacsimile or demand delivery. We are interested only in this class of items (and provide direct access to them) or to provide them by telefacsimile or demand delivery.

First consider telefacsimile versus purchase. Because the cost of each alternative is a function of the expected rate of use of an item (or group of items) it is possible to determine the level of expected usage at which it is less expensive to provide telefacsimile service for the item than to provide it by prior purchase.

The average cost of each individual telefacsimile usage is equal to the total cost of the telefacsimile installation over a given period (let us use a one-year period throughout this discussion) divided by the total number of requests handled during the period. Expressed mathematically, this cost per telefacsimile use (T) is:

$$T = A/Q$$

where:

A = annual cost of the telefacsimile system

and:

Q = the number of requests handled via telefacsimile during the year

The cost of servicing a previously purchased item is equal to the initial purchase and processing cost of the item, divided by the life expectancy (or period of amortization) of the item, plus the annual storage cost of the item, divided by the number of rush uses it experiences per period (year). Symbolically expressed, this cost per direct-access use (D) is:

$$D = \frac{(F + G)/K + S}{X}$$

where:

F = the initial purchase cost of the item
G = the processing cost of the item
K = the period of amortization of the item (or its life expectancy) in years
S = the annual storage cost of the item
X = the number of uses the item experiences per year

This expression shows that the lower the use, the greater the cost per direct-access use. The two equations may be used to calculate the level of usage where it becomes no more expensive to utilize telefacsimile than to purchase and maintain the item. We shall call this level the break-even point. It is calculated by creating an equality between the two equations as follows:

$$A/Q = \frac{(F + G)/K + S}{X}$$

In the above equation the unknown for which we shall solve is X, the annual usage. Rearranging, we obtain:

$$X = \frac{Q\ ((F + G)/K + S)}{A}$$

Let us solve the equation using a system where telefacsimile would cost $60,000 per annum, the number of rush requests during the year is 2000, item purchase and processing costs are each $10, storage cost $0.50 per annum, and the period of amortization is 40 years. The formula and values are:

$$X = \frac{Q\ ((F + G)/K + S)}{A}$$

where:

Q = 2000
F = 10
G = 10
K = 40
S = .5
A = 60,000

substituting we obtain:

$$X = \frac{2,000}{60,000}$$

$$X = 0.033 \text{ uses per year}$$

The result, X, is the break-even point. It indicates that, given the conditions we have set forth, the library can elect not to purchase items for which the expected use is less than one in thirty years and to provide these items, when requests occur, by telefacsimile.

In like manner, we could also calculate the break-even point in terms of the usage level for other access methods (such as special courier via the several transportation methods mentioned) in comparison with direct access. This break-even equation is:

$$Z = \frac{(F + G)/K + S}{X}$$

where:

Z = cost per request to service the request via any indirect access method

and the righthand side is the cost of a direct access alternative. Rearranging and solving for X we obtain:

$$X = \frac{(F + G)/K + S}{Z}$$

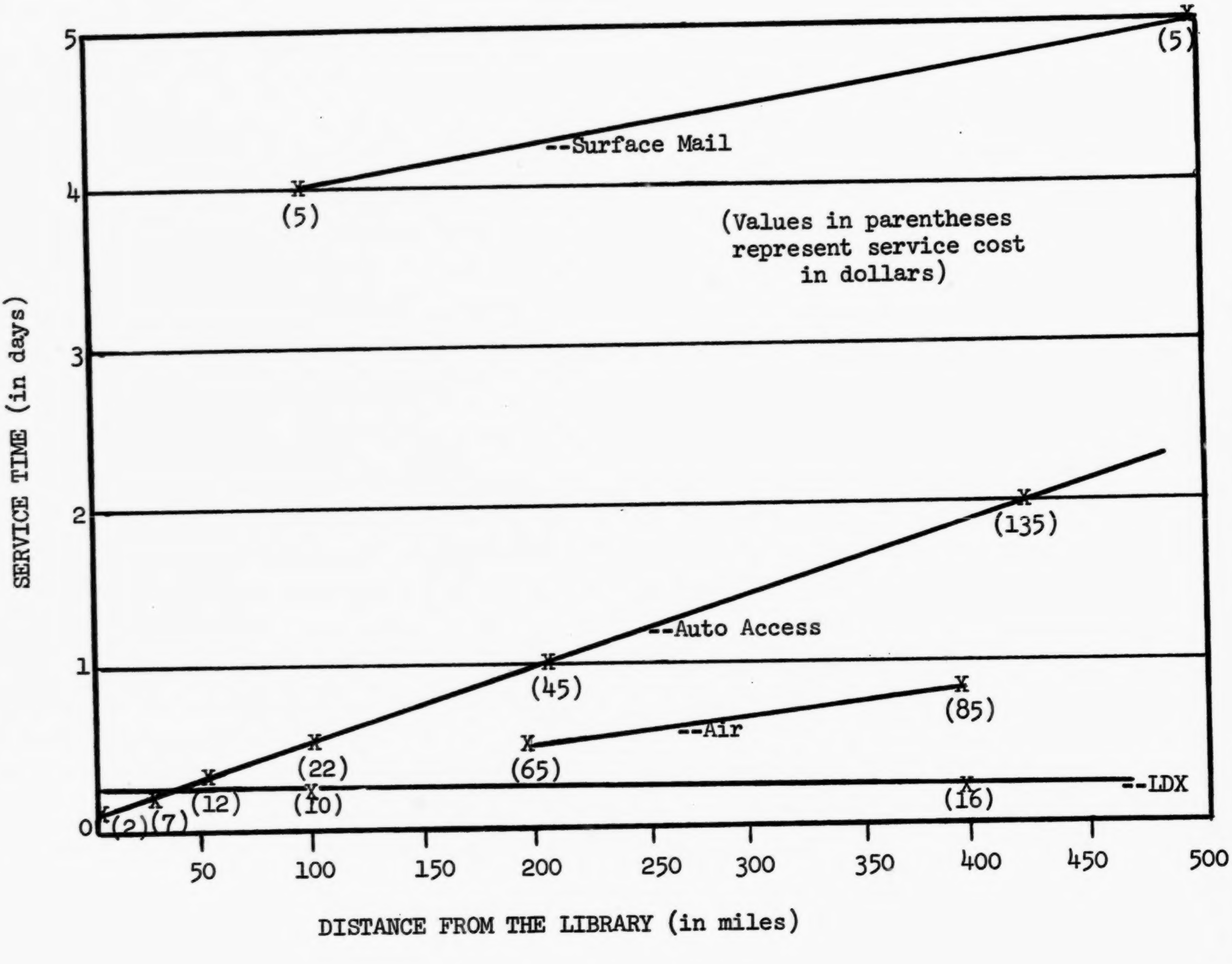
To obtain a value for Z we utilize Figure 42, which presents a graph showing the relationship of service time, distance, and cost for several indirect access methods. If, for example, we wished to use auto courier access over a distance of 100 miles, the service time would be approximately half a day, and the cost per request (shown in parentheses) would be $22.

If our library utilized two types of access--direct, and indirect via auto courier--we would then compute which class of materials to purchase and which to send via courier, using the equation above.

Substituting we obtain:

$$X = \frac{1}{22} = .045$$

FIGURE 42: RELATION OF SERVICE TIME
TO DISTANCE FROM LIBRARY BY ACCESS METHOD



So the class of items with a frequency of use of less than once every 22 years should be sent via courier; the more frequently used materials should be purchased.

This analysis demonstrates that the purchase of materials of low expected usage can be deferred and the demand for these materials supplied through indirect access using either telefacsimile or modified surface transport. Moreover, it is likely that surface transport will continue to be less expensive than telefacsimile for many years.

If materials are not urgently needed, they could be supplied more economically, and still within the requested deadline, by surface transport. Because of continuing expansion in educational facilities, the increasing demand upon libraries may eventually create a significant need for telefacsimile. In any event, the results of this study imply that the manual procedures used in delivery of interlibrary loan materials need to be reorganized. Such reorganization must take place before telefacsimile systems can effectively be used.

APPENDIX I: LDX PROCEDURES MANUAL

A. INTRODUCTION.

This manual of procedures describes in detail the implementation of the Xerox LDX Facsimile Project, Phase II, outlined in "A Proposal to the Council on Library Resources for a Research Grant to Conduct an Experiment in Library Application of Xerox LDX Facsimile Transmission Equipment" dated June 27, 1966.

The succeeding sections of this manual include:

B. General Description of Procedures
C. Flow Charts of Procedures
D. Control Sheet Examples
E. Sources for Verification

An important objective of the experiment is to reduce the delay between a library patron's request for material and his receipt of the desired copy.

In addition to Interlibrary Loan requests, selected samples of a variety of materials will be transmitted via LDX in order to test the quality and resolution.

B. GENERAL DESCRIPTION OF PROCEDURES.

An LDX request may originate from either of two sources: the individual requestor or the Interlibrary Loan staff at Davis (ILL-Davis). Except for a few minor variations (noted within the procedures) both types of requests are processed identically upon receipt at Berkeley.

Procedures for the processing of requests are as follows:

1. Request initiation (Davis)
2. Request receipt (Berkeley)
3. Location of material (Berkeley)
4. Retrieval of material (Berkeley)
5. Verification (Berkeley)
6. Extended processing (Berkeley)
7. LDX transmission (Berkeley)
8. Notification (Davis)
9. Pickup of materials (Davis)
10. Return of materials (Berkeley)

Each discussion of the procedures is divided into three parts: (1) a general description of the procedure; (2) a step-by-step outline of the procedure; and (3) a record of the time spent on the entire procedure and the individual steps within it.

There are three forms on which timings are recorded:

a. Item control sheet. For each item, the page records the time he begins and ends each step listed.

b. Batch control sheet. Using one form for each batch, the page records the time he begins and ends each procedure.

c. Transmission control sheet. For each item, the LDX operator records the transaction number, batch number, total number of pages, and time he begins and ends the copying and transmission. Only one control sheet is used for each day.

The LDX project transaction center is located at the Institute of Library Research (ILR), Building T-7, Room 206, Berkeley. Request calls from Davis are received at ILR and placed in the file box located there. Procedures 3 through 6 are referred to as the "processing cycle"; these are performed by an ILR page. Materials are copied and transmitted in Room 498 in the Annex of the Main Library Berkeley, by ILR. LDX copy (Procedure 8) is received and prepared for delivery on the fourth floor of the Main Library at Davis by the LDX Printer operator. Materials are picked up (Procedure 9) at the reference desk in the Davis Main Library.

1. Request Initiation (Davis). LDX requests are phoned in from Davis to Berkeley by either the individual requestor or the Interlibrary Loan staff at Davis.

Procedure: (1) Direct call by requestor. Before the LDX project was begun, letters were sent to Davis faculty members explaining the experiment. Journal article requests may be phoned directly to the LDX transaction center at ILR, Berkeley, by any faculty member (or graduate student) who has a department address and phone number. (2) ILL-Davis. If a journal article request is received by ILL-Davis, it is phoned to the LDX transaction center at ILR after verification and confirmation that the article is available at Berkeley. If the journal title is abbreviated, ILL will determine the full title prior to phoning Berkeley.

Timing: The time it takes the requestor to phone in his request is timed at Berkeley as part of the request receipt procedure (Procedure 2).

2. Request Receipt (Berkeley). Requests from Davis are received at the LDX transaction center by an ILR employee who records the necessary data on a special LDX project item control sheet.

Procedure: On an LDX project item control sheet, record the date. Then ask the requestor for the data listed below:

(a) Item identification

Call number
Location of material
Journal title
Author of article
Article title
Journal date and/or volume and issue number
Inclusive pages of article

(b) Source of item

(c) Requestor identification

First and last name
Department
Status of requestor
Telephone number for notification that material is ready to be picked up

Note whether request is being phoned in by ILL-Davis or by an individual requestor. Give the requestor the transaction number of his request, and tell him that in any further communication regarding this item, it will be identified by this transaction number. (Each LDX item control sheet will be prestamped with a transaction number.) Ask how much time the requestor spent getting on the tie line, and provide him with an estimate of turn-around time. Usually we will be able to service his request in two to four hours, although any request phoned in after 4 p.m. will not be ready for pickup until after 9 o'clock the next morning. When the call has been completed, place the item control sheet in the LDX request box.

Timing: Item control sheet--record the time that the call is received and the time that it is completed.

3. Location of Material (Berkeley). Item control sheets are picked up several times a day. At these times, a telephone call is placed to ILL-Davis to obtain any project requests which may have accumulated. Items are located by checking the public catalog, if necessary, prior to retrieval.

Procedure: Pick up the item control sheets from the file box at ILR. Write your initials, the day number (corresponding to the day of the month) and the batch number in the spaces provided on each item control sheet. Telephone ILL-Davis to determine whether they have received any journal requests for items available at Berkeley. If so, record each request on an item control sheet. Sort the requests into two groups: those with locations and those without locations. Look up those items for which you have no location in the Main Library catalog. Record the location and call number in the space provided on the control sheets. If you are unable to find a call number, mark "NF" (not found) in the upper right-hand corner of the call number space and remove the control sheet from the batch for verification (see Procedure E). Sort the sheets by location, plan a logical route for retrieval, and arrange the item control sheets accordingly.

Timing: (1) Item control sheet--record the times that lookup is begun and finished. (2) Batch control sheet--record the time the item control sheets are picked up (under "Begin processing"), the time of departure from ILR, the time of arrival at the public catalog (under "Begin look-up"), and the time that lookup is completed (under "End look-up").

4. Retrieval of Material (Berkeley). The volumes containing the requested articles are paged at their respective locations. After all items have been paged, they are taken to the LDX room.

Procedure: Go to the first location (according to the route plan decided upon in Procedure C). If an item at this location does not already have the call number on the item control sheet, obtain it from the departmental catalog. If you do not find an item in the departmental catalog, check to see if the requestor has given a source. If the source is at this location, check it. If the item is found and the citation is different from that on the control sheet, note the error and correct the citation. If the citation is the same or if you do not find the item, remove the control sheet from the batch for verification. If the requestor's source is located elsewhere, plan to go to that location as conveniently as possible during retrieval. If the requestor has not given the source, set the control sheet aside for local verification (if this seems advisable) or for verification in the Main Library at the end of the processing cycle. At each location, sort items into call number order. Page each item at that location. Place the item control sheet in the journal at the point where the requested article begins. Charge items found on the shelf to "LDX Project". (For this purpose, a special proxy card has been issued in the name of the project director.) For items not found on the shelf, check the charge files. If an item is charged out and it is available at another location, plan to go to that location when it fits most logically into your retrieval route. If the item will be available within 24 hours, and it is not available at another location, place a "hold" and check the "hold" box on the item control sheet. Return the control sheet to the file box in ILR with a note attached indicating the time that the document will be available. If it will not be available within 24 hours, note on the item control sheet that the request is "non-serviceable" by checking the NS box. The item control sheet should be returned to the LDX room. If the item is not found in the charge file, look up the item in the departmental catalog (if the call number was not obtained locally). If the call number is different, correct the item control sheet. Page the item and proceed as above. If the preceding fails, and the requestor's source is indicated on the sheet, and the indicated source is available at this location, check it. If the citation is different, note the error, correct the control sheet, check the item again in the local catalog, and page the item. If further assistance is needed and is available locally, e.g., if a librarian or circulation clerk is present, ask for help. If further assistance is not available locally, and the journal is available at another location, note the location, set the control sheet aside, and go to that location when it fits most logically into your retrieval route. If the journal is not available at another location and further verification is possible at the Main Library or another location, mark the sheet to indicate that there must be further verification. Proceed to the next location if additional items are at other locations. After all requests in the batch have been paged, take the materials to the LDX room for transmission.

Timing: (1) Item control sheet--record the times that you begin and end catalog look-up, paging and local verification of each item. (2) Batch control sheet--record the time you arrive at the first location, the time you leave the last location, and the time you arrive at the LDX room with the documents.

location, sort items into call number order. Page each item at that location. Place the item control sheet in the journal at the point where the requested article begins. Charge items found on the shelf to "LDX Project". (For this purpose, a special proxy card has been issued in the name of the project director.) For items not found on the shelf, check the charge files. If an item is charged out and it is available at another location, plan to go to that location when it fits most logically into your retrieval route. If the item will be available within 24 hours, and it is not available at another location, place a "hold" and check the "hold" box on the item control sheet. Return the control sheet to the file box in ILR with a note attached indicating the time that the document will be available. If it will not be available within 24 hours, note on the item control sheet that the request is "non-serviceable" by checking the NS box. The item control sheet should be returned to the LDX room. If the item is not found in the charge file, look up the item in the departmental catalog (if the call number was not obtained locally). If the call number is different, correct the item control sheet. Page the item and proceed as above. If the preceding fails, and the requestor's source is indicated on the sheet, and the indicated source is available at this location, check it. If the citation is different, note the error, correct the control sheet, check the item again in the local catalog, and page the item. If further assistance is needed and is available locally, e.g., if a librarian or circulation clerk is present, ask for help. If further assistance is not available locally, and the journal is available at another location, not the location, set the control sheet aside, and go to that location when it fits most logically into your retrieval route. If the journal is not available at another location and further verification is possible at the Main Library or another location, mark the sheet to indicate that there must be further verification. Proceed to the next location if additional items are at other locations. After all requests in the batch have been paged, take the materials to the LDX room for transmission.

Timing: (1) Item control sheet--record the times that you begin and end catalog look-up, paging and local verification of each item. (2) Batch control sheet--record the time you arrive at the first location, the time you leave the last location, and the time you arrive at the LDX room with the documents.

5. Verification (Berkeley). After all other items in the batch have been paged and taken to the LDX room, the items that the page was unable to identify or locate are verified.

Procedure: If the requestor's source has not been verified previously and it is indicated on the item control sheet, locate the source in the Main Library and check it to determine whether the item has been correctly identified by the requestor. If the item is listed in the source and the citation in the source is different (and presumably correct), correct the data which appear on the item control sheet. If the correction suggests that the item might now be found in the public catalog, note on the control sheet that the item should be looked up again in the public catalog. If the requestor's source is not given, or if upon looking up the citation in his source you either do not find it or note that it was given incorrectly, further verification is necessary. In general, there should be an attempt to find a source which lists the item under its "correct" form of entry. If the citation which you have on the item control sheet differs from the correct one listed in the source, correct the entry appearing on the item control sheet and note on the sheet that this item will require another catalog look-up under its correct form of entry. If you have not been able to find the item in the standard sources, mark on the sheet that the item is non-serviceable, and check the appropriate box on the item control sheet. Indicate also the sources which were checked during the verification procedure. After all items have been verified, look for the item under the corrected entry in the main public catalog. If the item is listed, note the call number and location of the item, and indicate on the sheet that it must be paged during the next processing cycle. Mark all items which were not located as non-serviceable items. Copies of the item control sheet will be transmitted to Davis to serve as a report on these non-serviceable transactions. This completes the normal processing cycle. Return to ILR to pick up the next batch of requests.

Timing: (1) Item control sheet--record the time you begin and complete the verification of an item. Do not forget to record other times, e.g., catalog look-up, on the sheet. (2) Batch control sheet--, record the times you begin and complete verification of all items in a batch.

6. Extended Processing (Berkeley). At this point, some items may need additional processing.

Procedure: If extended processing may make it possible to find an item proviously not found, e.g., if a citation error is found through verification, the page should do whatever is appropriate: additional verification, look-up, or repaging. If there is an error in copying or transmission, the LDX operator should do any recopying or retransmission which may be necessary.

Timing: (1) Item control sheet--record under the appropriate process the times you begin and finish. (2) Batch control sheet--record the times that you begin and end recopying or retransmission. Note that the process is being repeated.

7. LDX Transmission (Berkeley). Xerox copies are made of the journal article on the 914 Copier by the LDX operator. Then the item control sheet and the 914 copy of the document are transmitted over the LDX.

Procedure: (Serviced items) Remove the item control sheet from the journal. Compare the citation and call number on the control sheet with the journal itself. Note the inclusive pages desired (indicated on the control sheet) and enter the total number of pages in the upper right-hand corner of the item control sheet. Xerox the inclusive journal pages on the 914 Copier. Transmit both the item control sheet and the 914 copy of the document on the LDX. Be sure to transmit the control sheet before the document. Prepare and send to the requestor the 914 copy of the document and a service questionnaire. Check the upper right-hand corner of the item control sheet to determine the total number of pages and count to see that they are all there. Collate and staple. Enter the data required on the top sheet of the questionnaire. Place in an envelope and address--requestor's name, status, department, Davis campus. Seal the envelope and place it in the outgoing mail box (to be picked up by the page when incoming materials are delivered).

For non-serviced items the item control sheet will not be accompanied by a journal. Check to see that the item control sheet indicates that the item is not being sent, mark a large "X" in the upper right-hand corner, and transmit the sheet twice over the LDX.

Timing: (1) Item control sheet--record the times you begin and finish making 914 copies and the times you begin and finish transmitting material over the LDX. (2) Transmission control sheet--for each item, record the transaction number, total number of pages and the times you begin and end the copying and LDX transmission.

8. Notification (Davis). Incoming LDX copy is received, prepared and routed by the LDX operator.

Procedure: Determine what type of material is being transmitted. If it is an LDX project journal request (identified by the item control sheet), determine whether it is "serviced" or "non-serviced". For "serviced" items, the total number of pages in the document will appear in the upper right-hand corner. Collate and count the number of pages to make sure that the item is complete. Staple the document with the item control sheet affixed on top. Phone the requestor. If the requestor phoned directly, inform him that his journal request (identified by its transaction number) is ready and may be picked up at the reference desk in a few minutes. For "non-serviced" items, an "X" will appear in the upper right-hand corner. Collate and staple the two copies of each item control sheet. An individual who requested an item directly should be phoned and informed that his LDX request (identified by its transaction number) could not be filled by LDX and is being send to ILL for processing through the normal Interlibrary Loan channels. After all phone calls have been made, deliver the batch of serviced items to the reference desk. At the same time, pick up the item control sheets (which have been retained by the clerk at the reference desk) from the previous batch. Take non-serviced item control sheets to ILL. Have the ILL clerk sign the top sheets, which should be retained and returned to the LDX room. The duplicate sheets are to be left with ILL.

Timing: Item control sheet--record the time that you begin phoning a requestor, the number of calls you make, and the time you reach him.

9. Pickup of Materials (Davis). Requests phoned directly by the requestor are picked up at the reference desk in the Main Library on the Davis campus.

Procedure: Requestor comes to the reference desk to pick up his LDX-transmitted journal article. Reference clerk asks for the transaction number (or other identification), retrieves the document, asks the requestor to sign his name, the date, and time, tears off the item control sheet and retains it for the LDX operator, and gives the requestor his document.

Timing: Item control sheet--the person who picks up the material enters the time that the item is received.

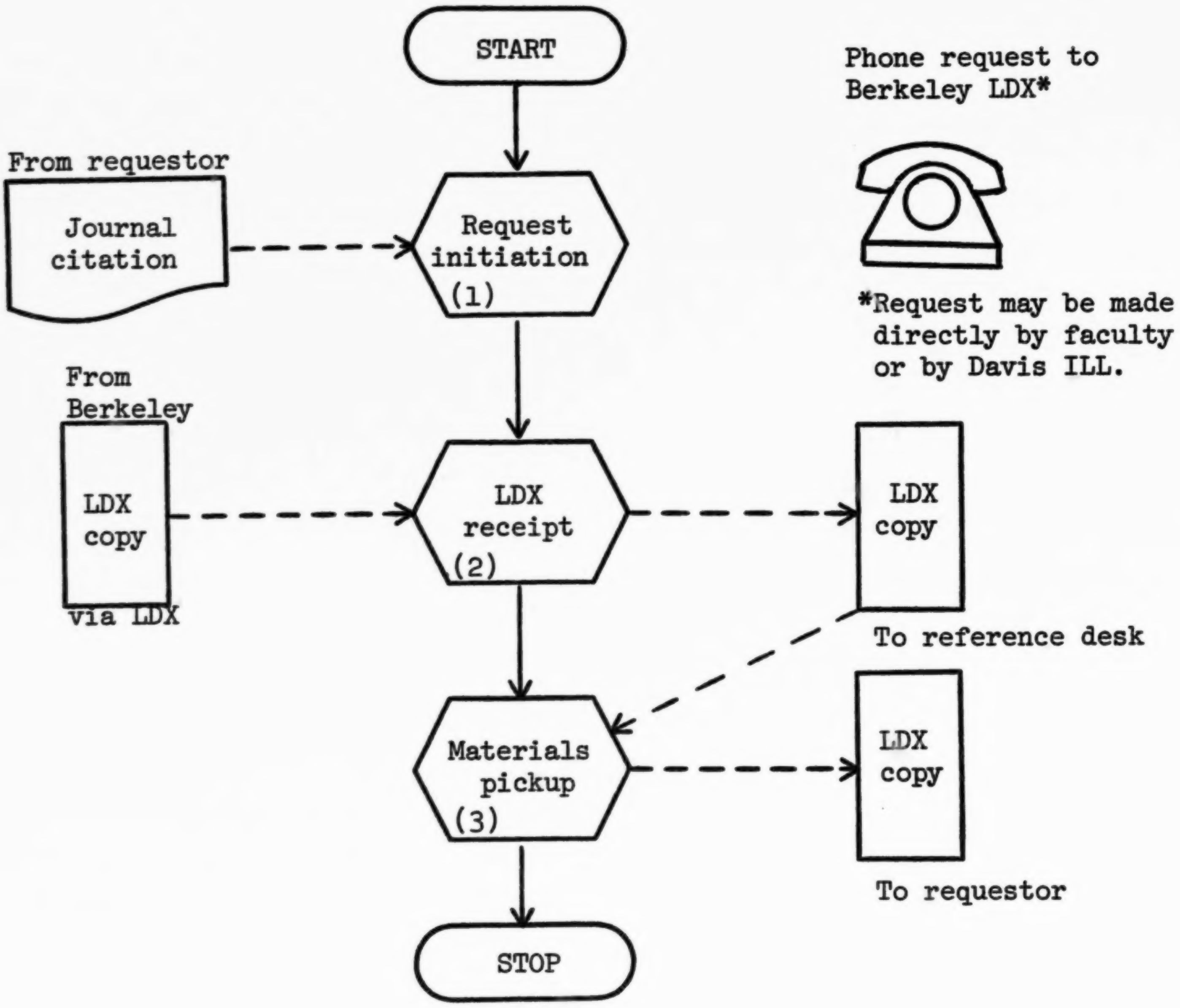
10. Return of Materials (Berkeley). The journals are picked up by the page from the LDX room, during the "dead" periods or during the last working hour (4 p.m. to 5 p.m.) each day (whichever is more convenient) and are returned to their respective locations.

Procedure: Go to the LDX room and pick up the journals to be returned. Sort journals which are due by the end of the day into groups corresponding to the branch libraries from which they were charged. Return journals not due by the end of the day to the Loan Desk in the Main Library. Then return remaining journals to their locations.

Timing: Batch control sheet--record the time of departure from the LDX room and the time that you return to ILR.

C. FLOW CHARTS OF PROCEDURES.

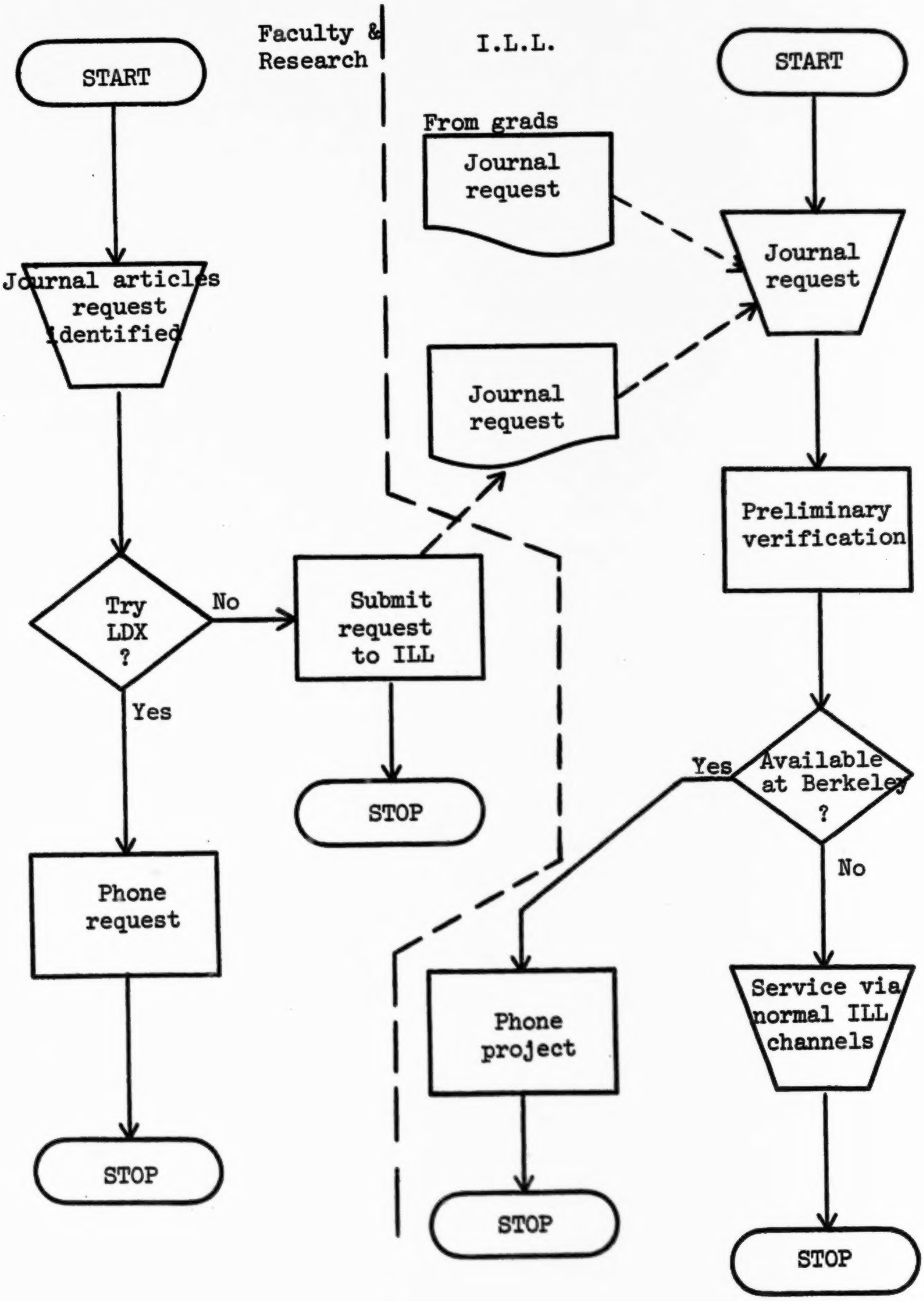
General Flow - Davis


START
Phone request to Berkeley LDX*
From requestor
Journal citation
Request initiation (1)
*Request may be made directly by faculty or by Davis ILL.
From Berkeley
LDX copy
via LDX
LDX receipt (2)
LDX copy
To reference desk
Materials pickup (3)
LDX copy
To requestor
STOP

Step	Operation	Location	Procedure
1	Request Initiation	(1) Davis ILL (2) Davis Campus	(New)
2	LDX Receipt	LDX Room	(New)
3	Materials Pickup	Reference Desk	(New)

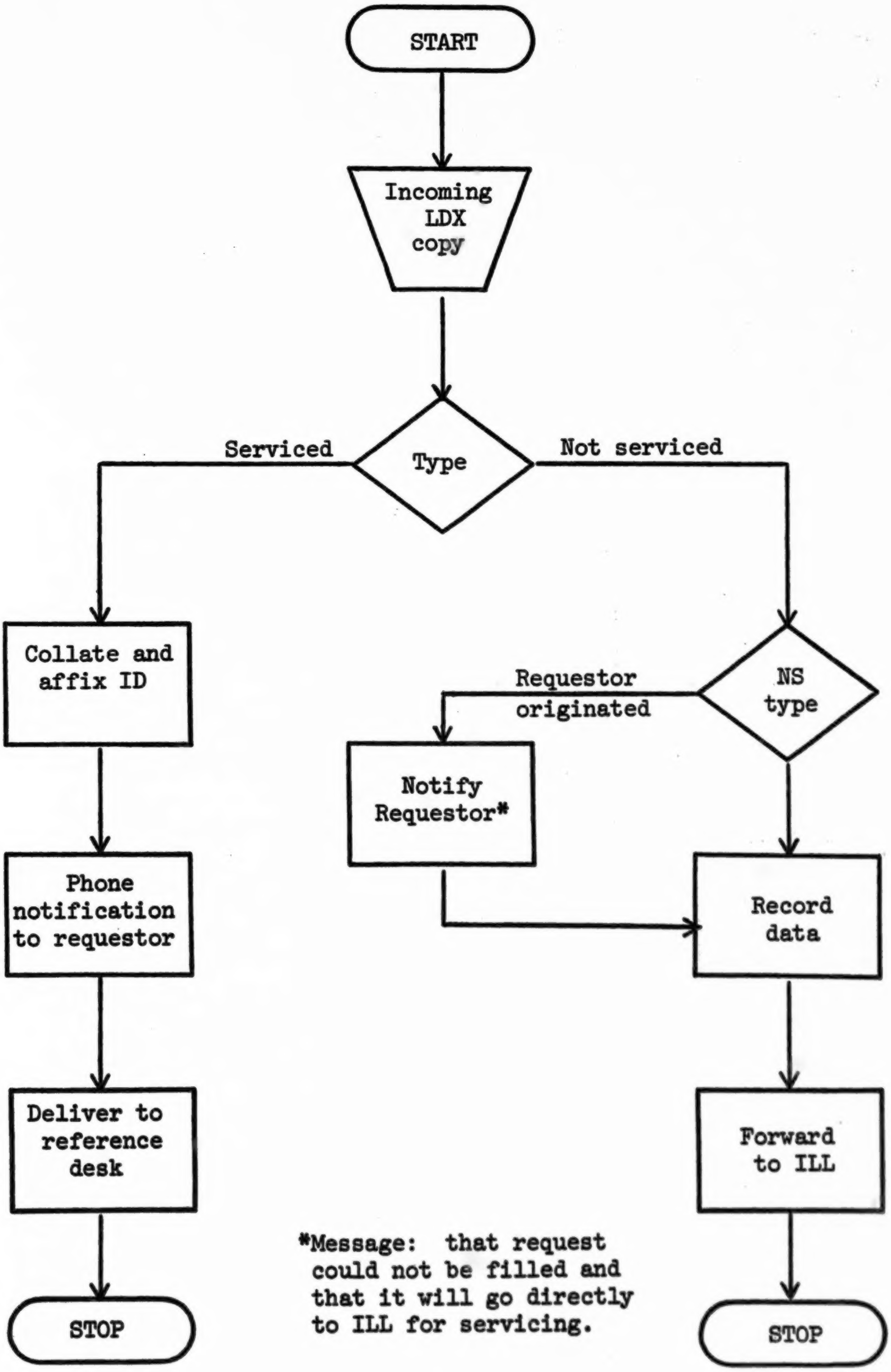
Detailed Charts - Davis

(1) Request Generation


Faculty & Research
I.L.L.
START
Journal articles request identified
Try LDX ?
No
Yes
Submit request to ILL
STOP
Phone request
STOP
From grads
Journal request
Journal request
START
Journal request
Preliminary verification
Available at Berkeley ?
Yes
No
Phone project
STOP
Service via normal ILL channels
STOP

Detailed Charts - Davis (Cont.)

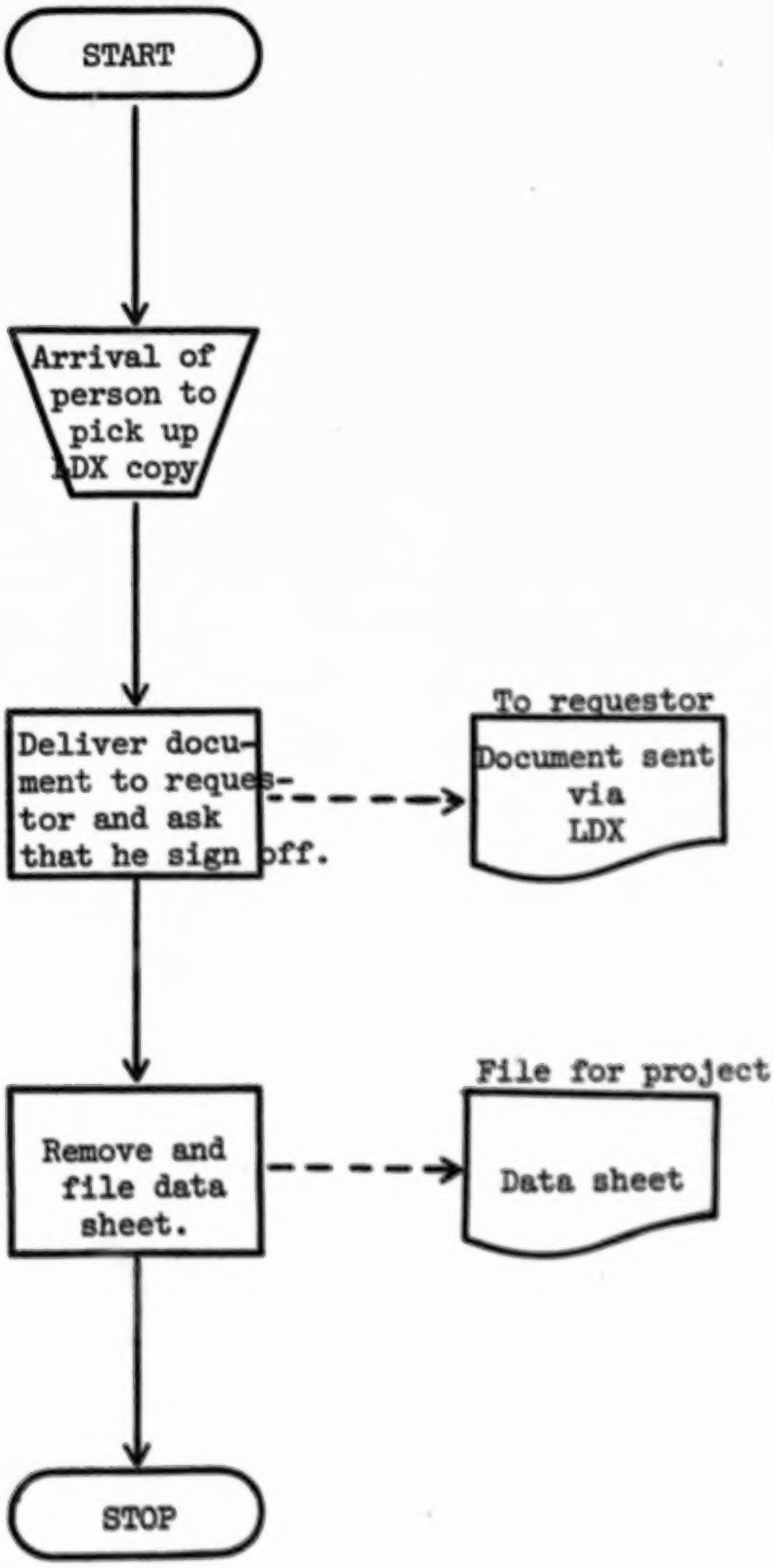
(2) LDX Copy Receipt (4th Floor Library)


START
Incoming LDX copy
Type
Serviced
Not serviced
Collate and affix ID
Phone notification to requestor
Deliver to reference desk
STOP
NS type
Requestor originated
Notify Requestor*
Record data
Forward to ILL
STOP

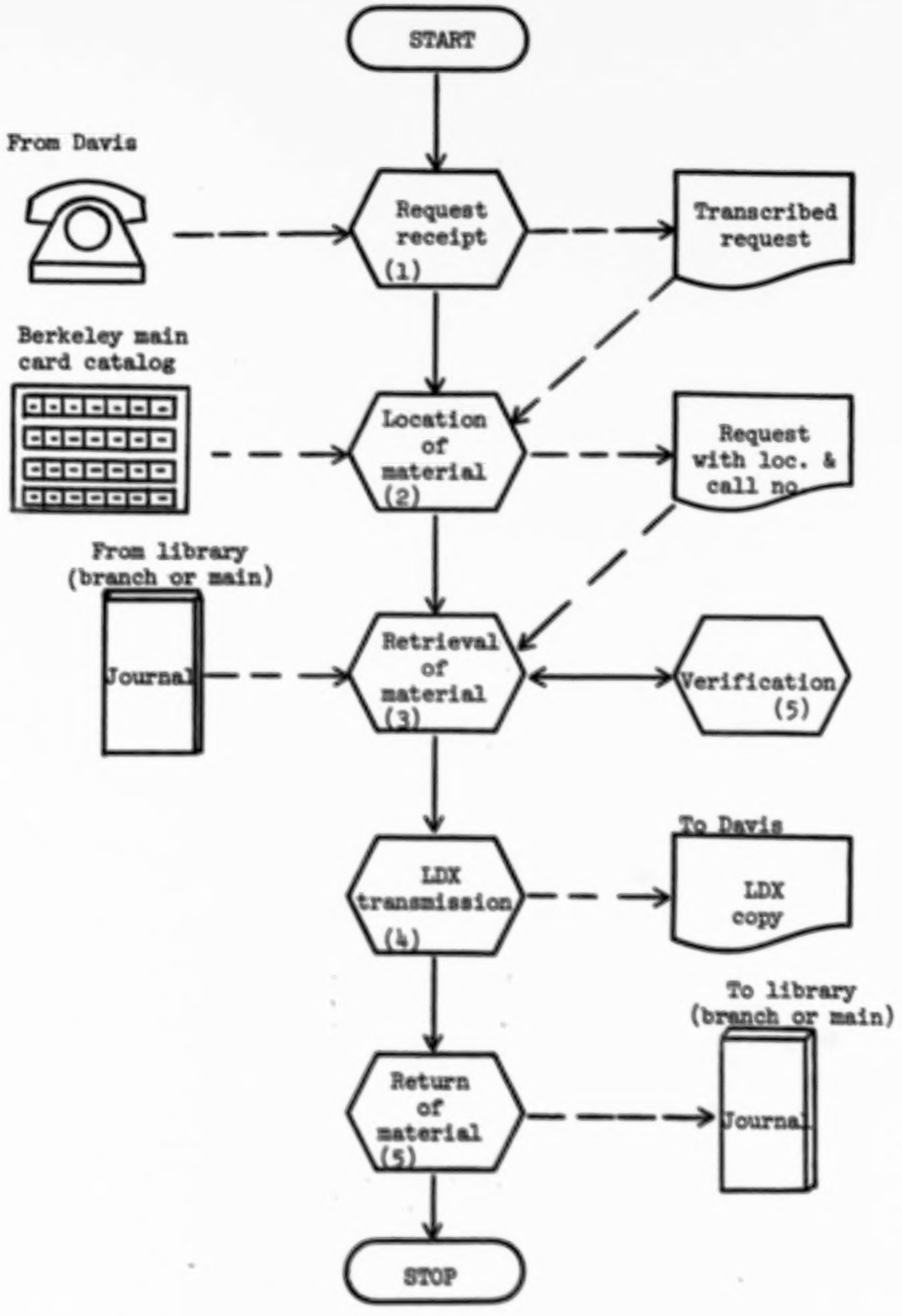
*Message: that request could not be filled and that it will go directly to ILL for servicing.

Detailed Charts - Davis (Cont.)

(3) Materials Pickup (Reference Desk)


START
Arrival of person to pick up LDX copy
Deliver document to requestor and ask that he sign off.
To requestor
Document sent via LDX
Remove and file data sheet.
File for project
Data sheet
STOP

General Flow - Berkeley

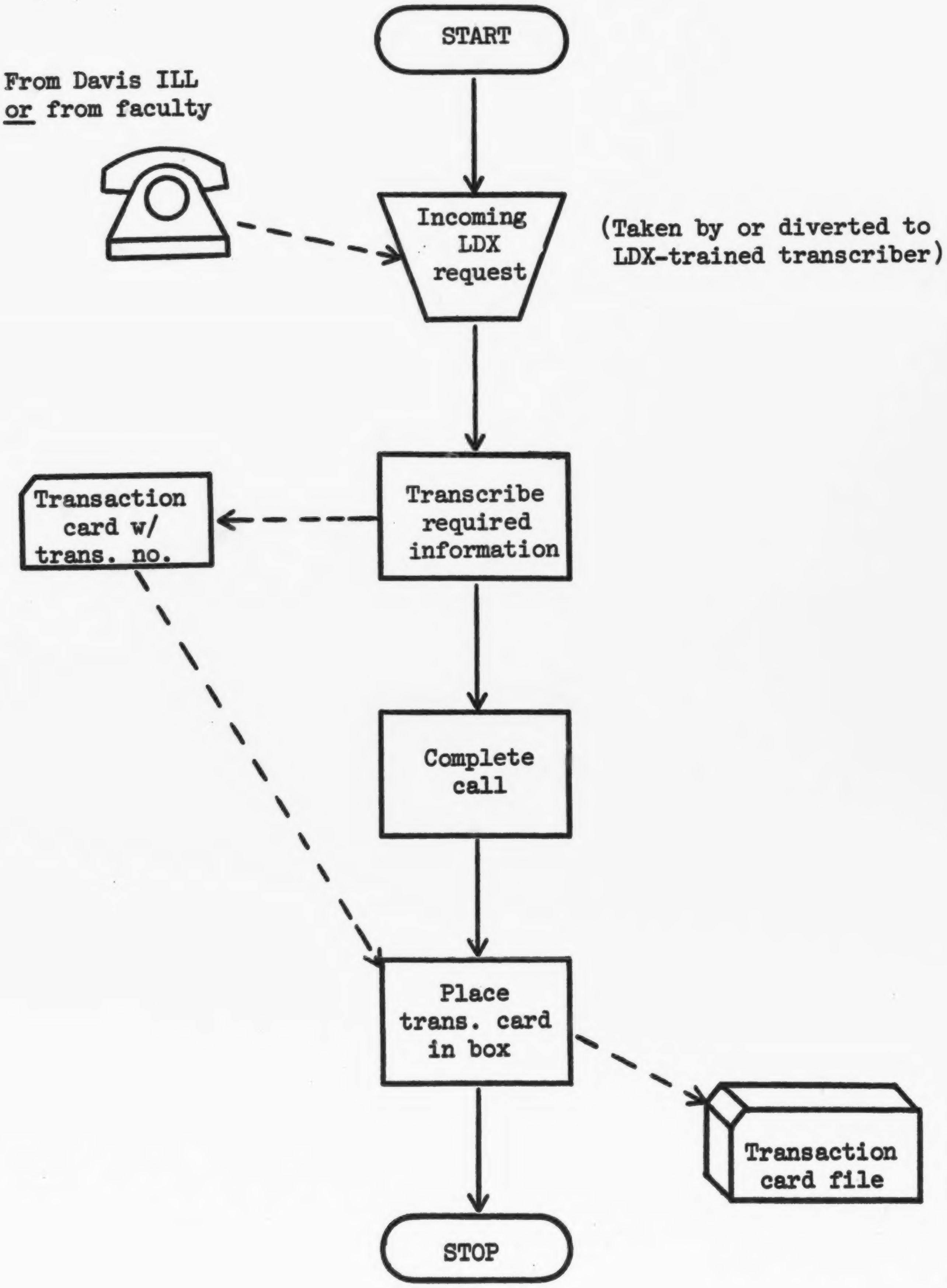

START
From Davis
Request receipt (1)
Transcribed request
Berkeley main card catalog
Location of material (2)
Request with loc. & call no.
From library (branch or main)
Journal
Retrieval of material (3)
Verification (5)
To Davis
LDX transmission (4)
LDX copy
To library (branch or main)
Return of material (5)
Journal
STOP

General Flow - Berkeley (Cont.)

Step	Operation	Location	Procedure
1.	Request Receipt A. Manual B. Automatic	ILR	Intercampus Circulation Phase II
2.	Location of Material	Main Catalog Library	ILL
3.	Retrieval of Material A. Transportation B. Charging C. Transit	From Branch and Main Libraries	(New)
4.	LDX Transmission A. 914 Copy B. Requestor I.D. C. Sending, LDX	Room 498 Library	(New with Assistance from Xerox)
5.	Return of Materials	To Branch and Main Libraries	(New)
6.	Verification	Main Library	(ILL)

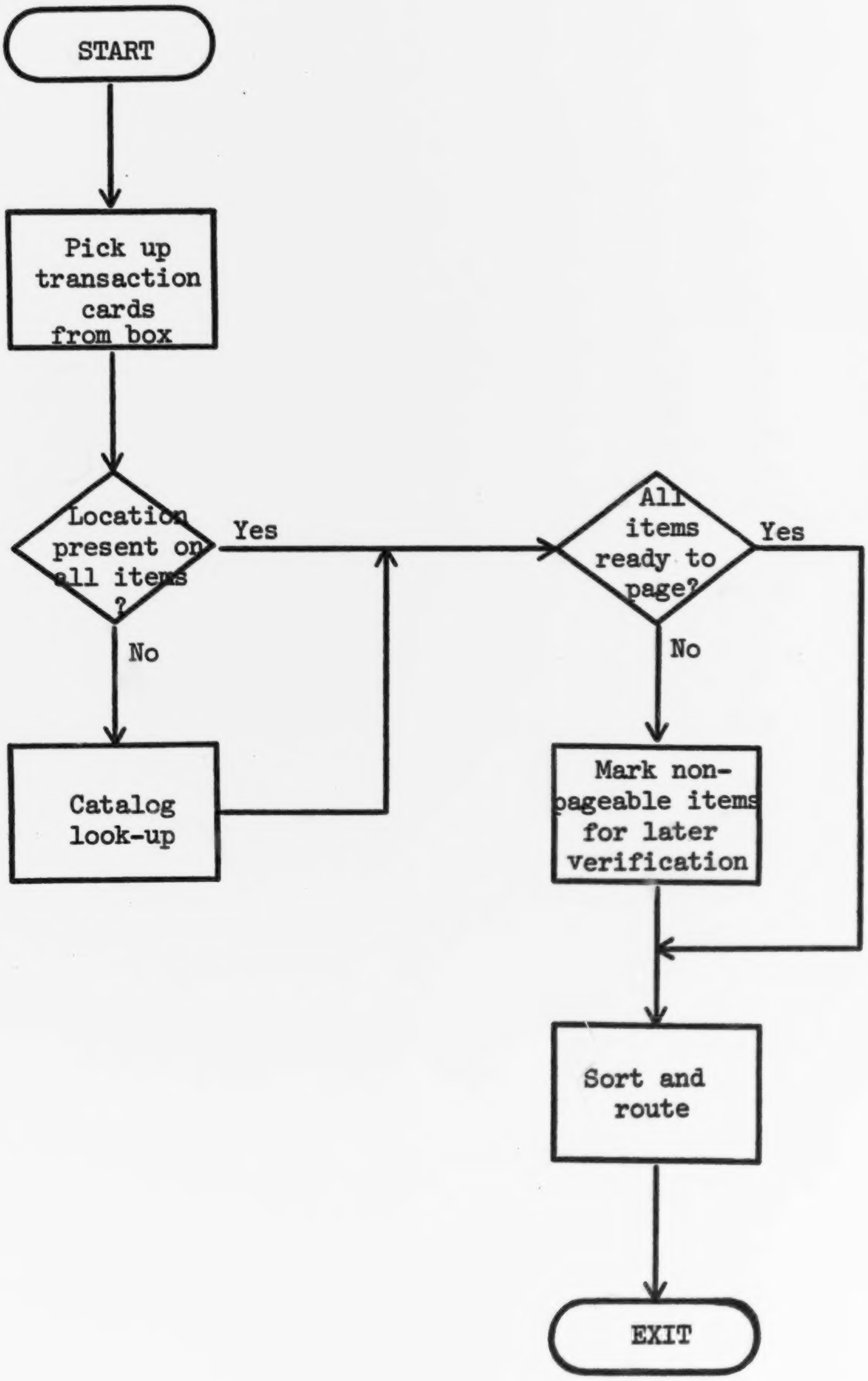
Detailed Charts - Berkeley

(1) Request Receipt (Item)


START
From Davis ILL
or from faculty
Incoming
LDX
request
(Taken by or diverted to
LDX-trained transcriber)
Transaction
card w/
trans. no.
Transcribe
required
information
Complete
call
Place
trans. card
in box
Transaction
card file
STOP

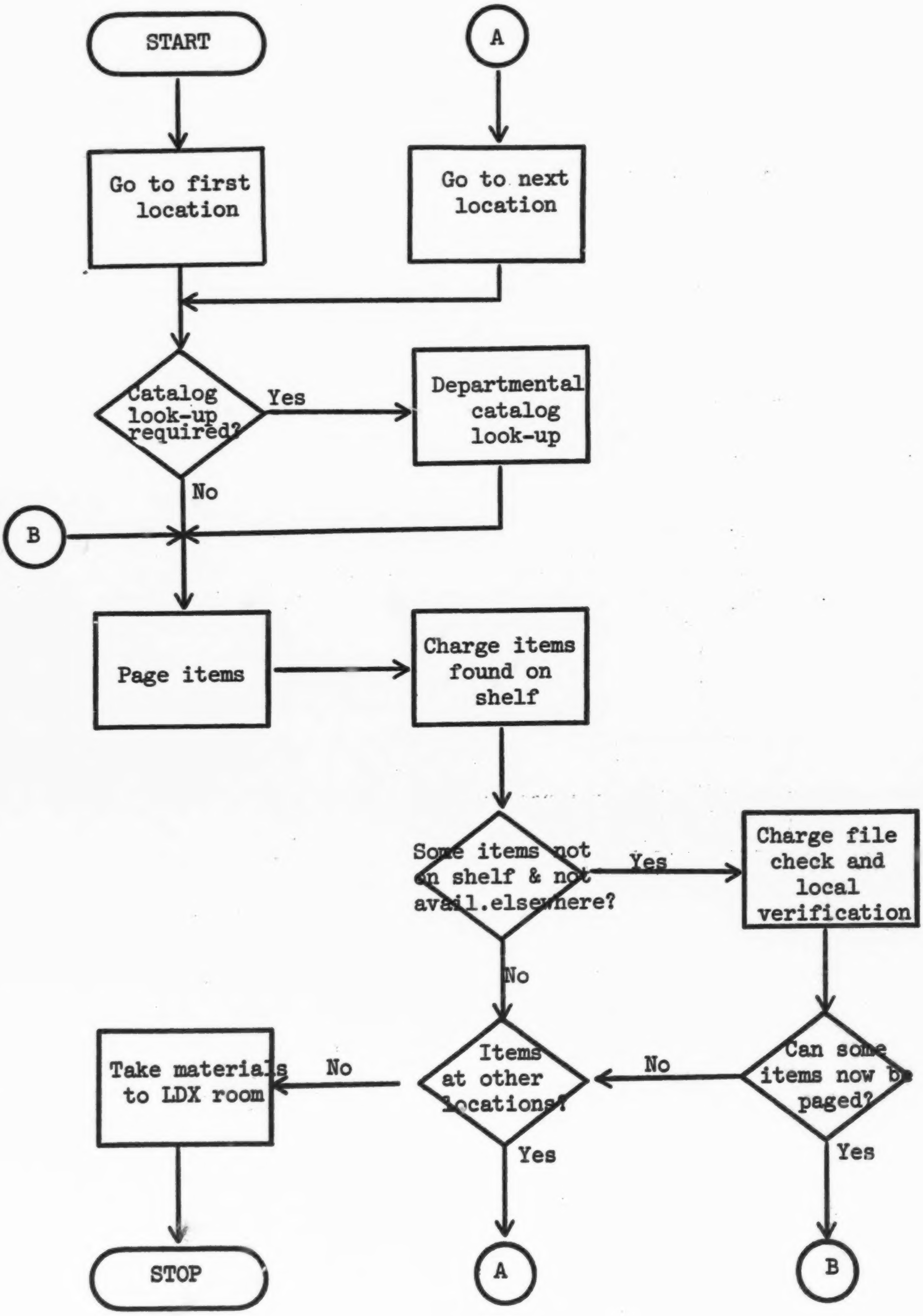
Detailed Charts - Berkeley (Cont.)

(2) Location of Material (Batch)

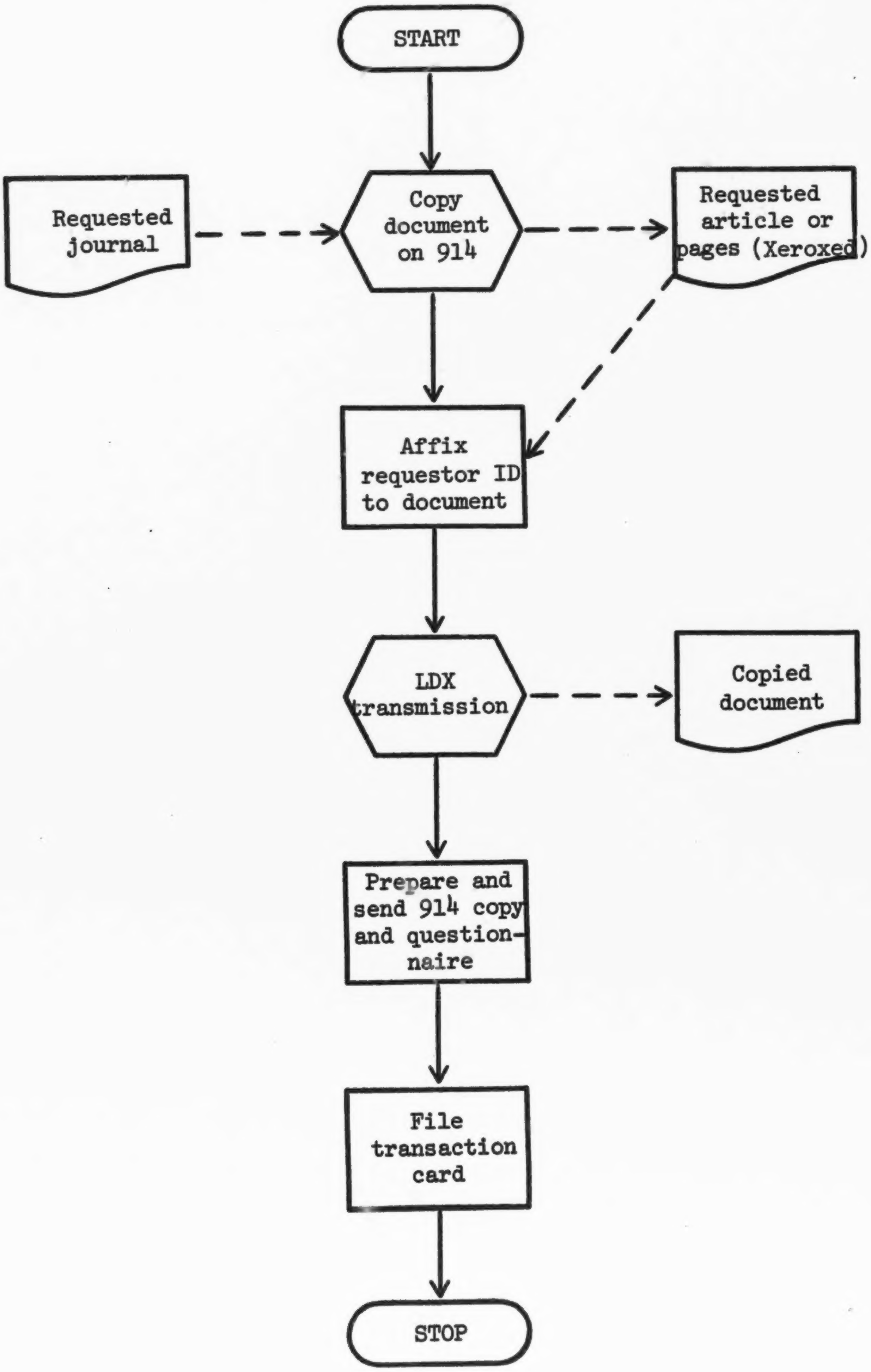

START
Pick up transaction cards from box
Location present on all items ?
Yes
No
Catalog look-up
All items ready to page?
Yes
No
Mark non-pageable items for later verification
Sort and route
EXIT

Detailed Charts - Berkeley (Cont.)

(3) Retrieval of Materials (Batch)

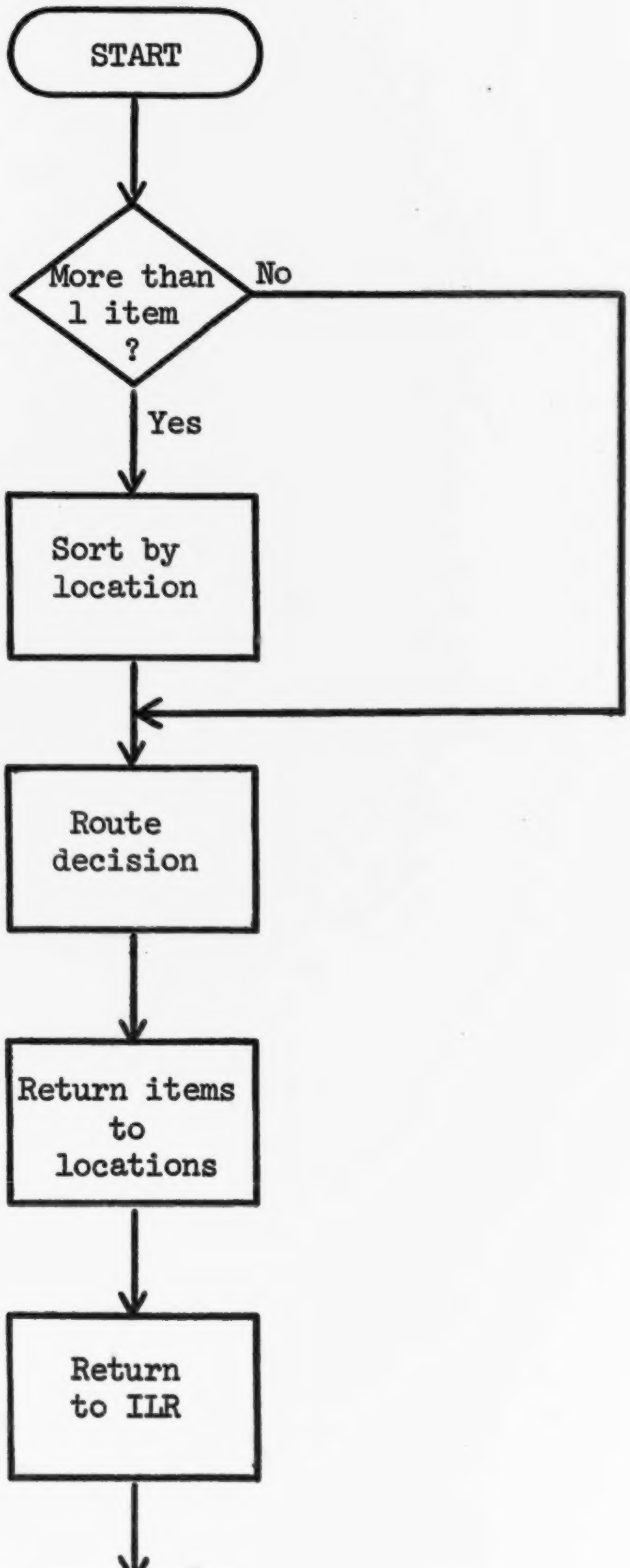

START
A
Go to first location
Go to next location
Catalog look-up required?
Yes
Departmental catalog look-up
No
B
Page items
Charge items found on shelf
Some items not on shelf & not avail.elsewhere?
Yes
Charge file check and local verification
No
Take materials to LDX room
No
Items at other locations?
No
Can some items now be paged?
Yes
Yes
STOP
A
B

Detailed Charts - Berkeley (Cont.)
(4) LDX Transmission (Item)


START
Requested journal
Copy document on 914
Requested article or pages (Xeroxed)
Affix requestor ID to document
LDX transmission
Copied document
Prepare and send 914 copy and questionnaire
File transaction card
STOP

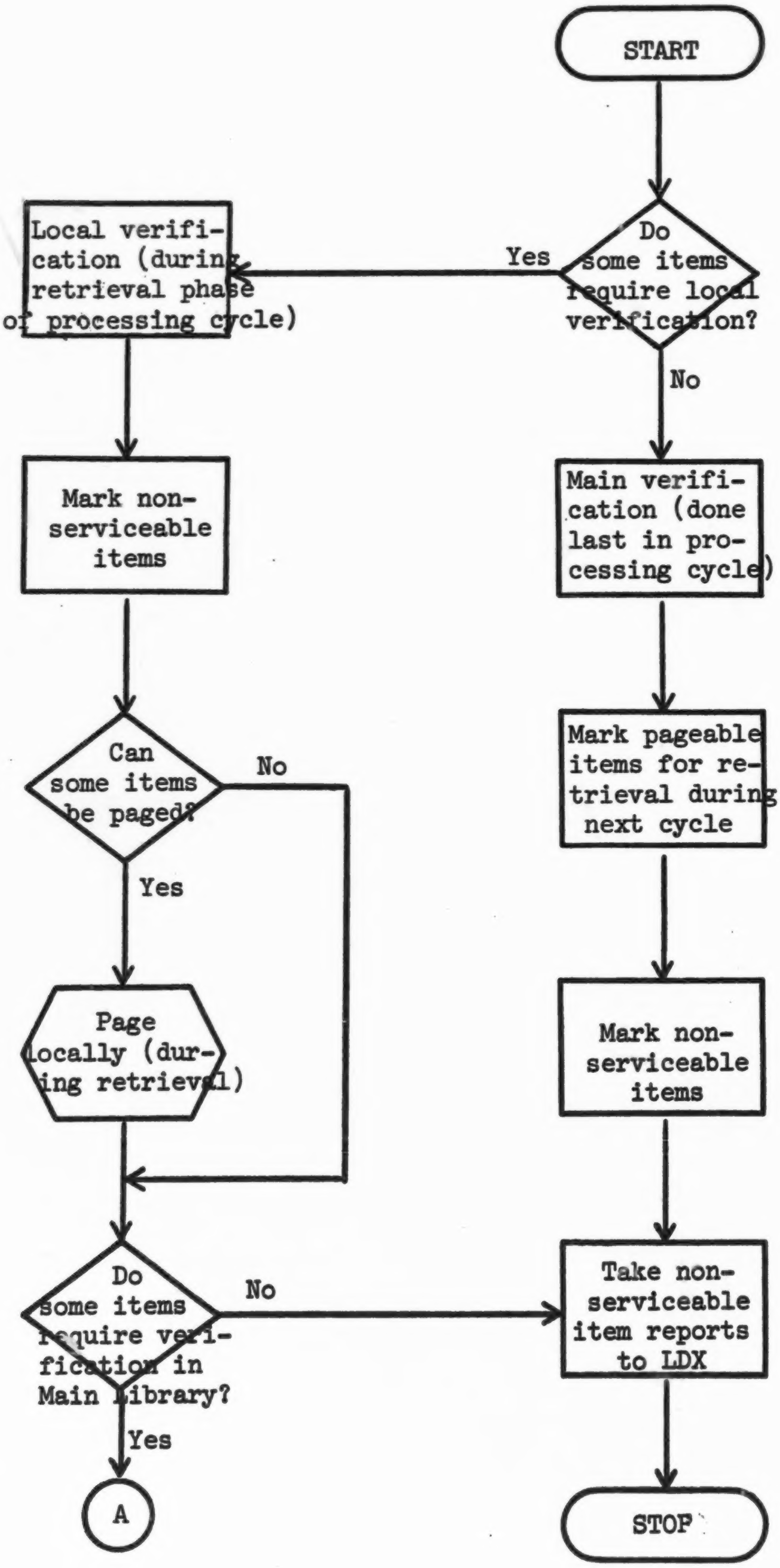
Detailed Charts - Berkeley (Cont.)

(5) Return of Materials (Batch)

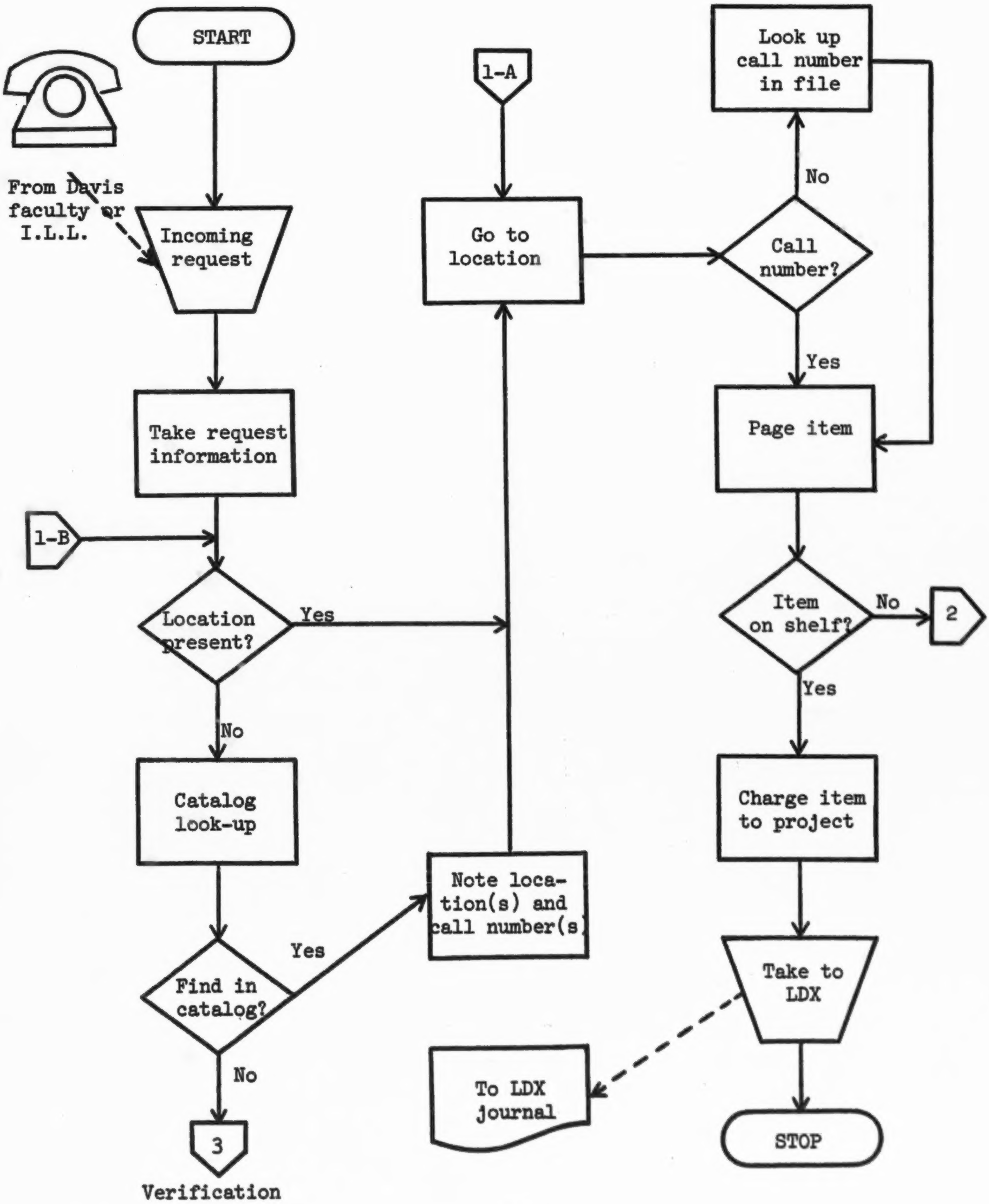

START
More than 1 item ?
No
Yes
Sort by location
Route decision
Return items to locations
Return to ILR
STOP

Detailed Charts - Berkeley (Cont.)

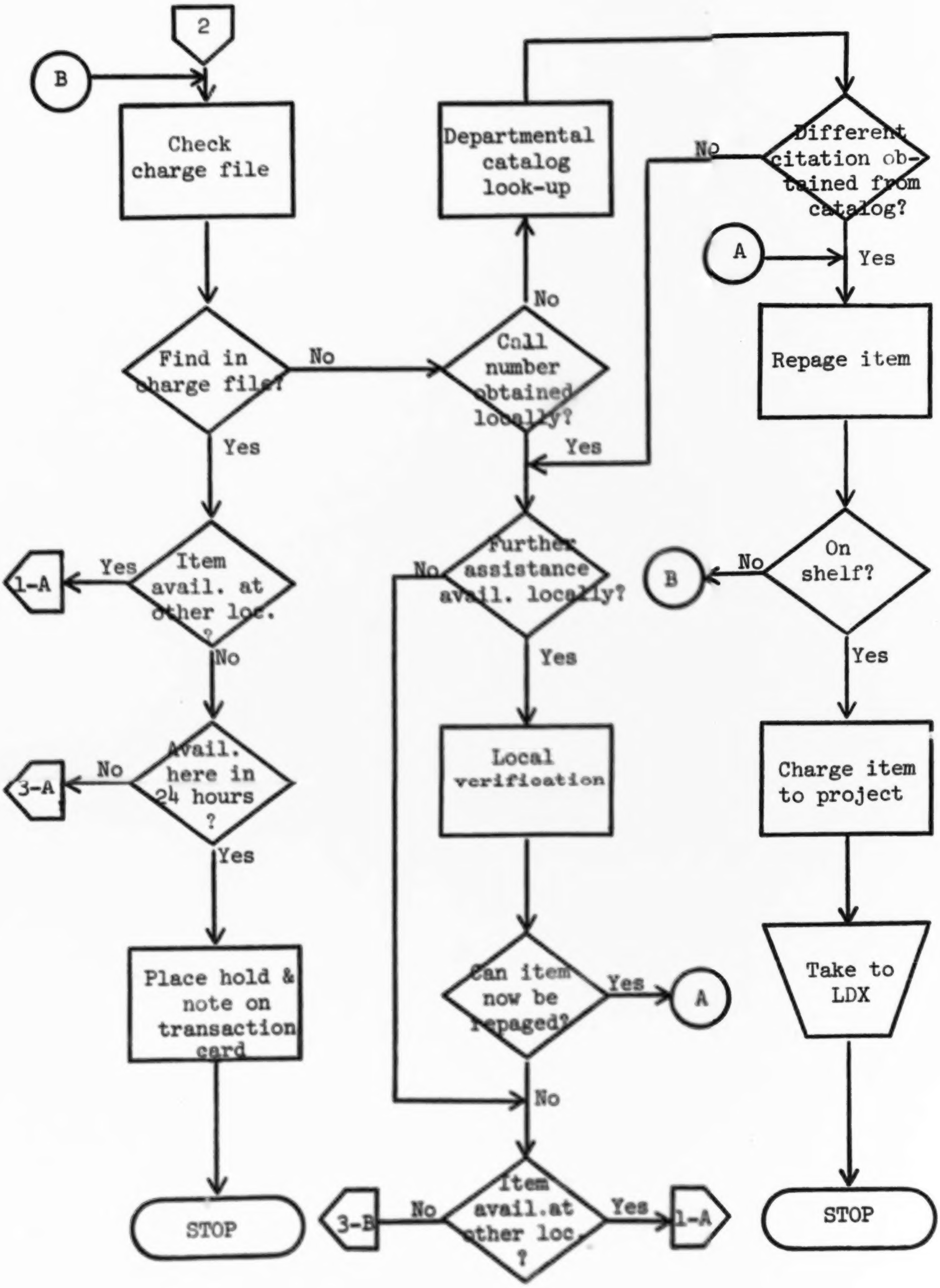
(6) Verification (Batch)


START
Do some items require local verification?
Yes
Local verification (during retrieval phase of processing cycle)
No
Mark non-serviceable items
Main verification (done last in processing cycle)
Can some items be paged?
No
Mark pageable items for retrieval during next cycle
Yes
Page locally (during retrieval)
Mark non-serviceable items
Do some items require verification in Main Library?
No
Take non-serviceable item reports to LDX
Yes
A
STOP

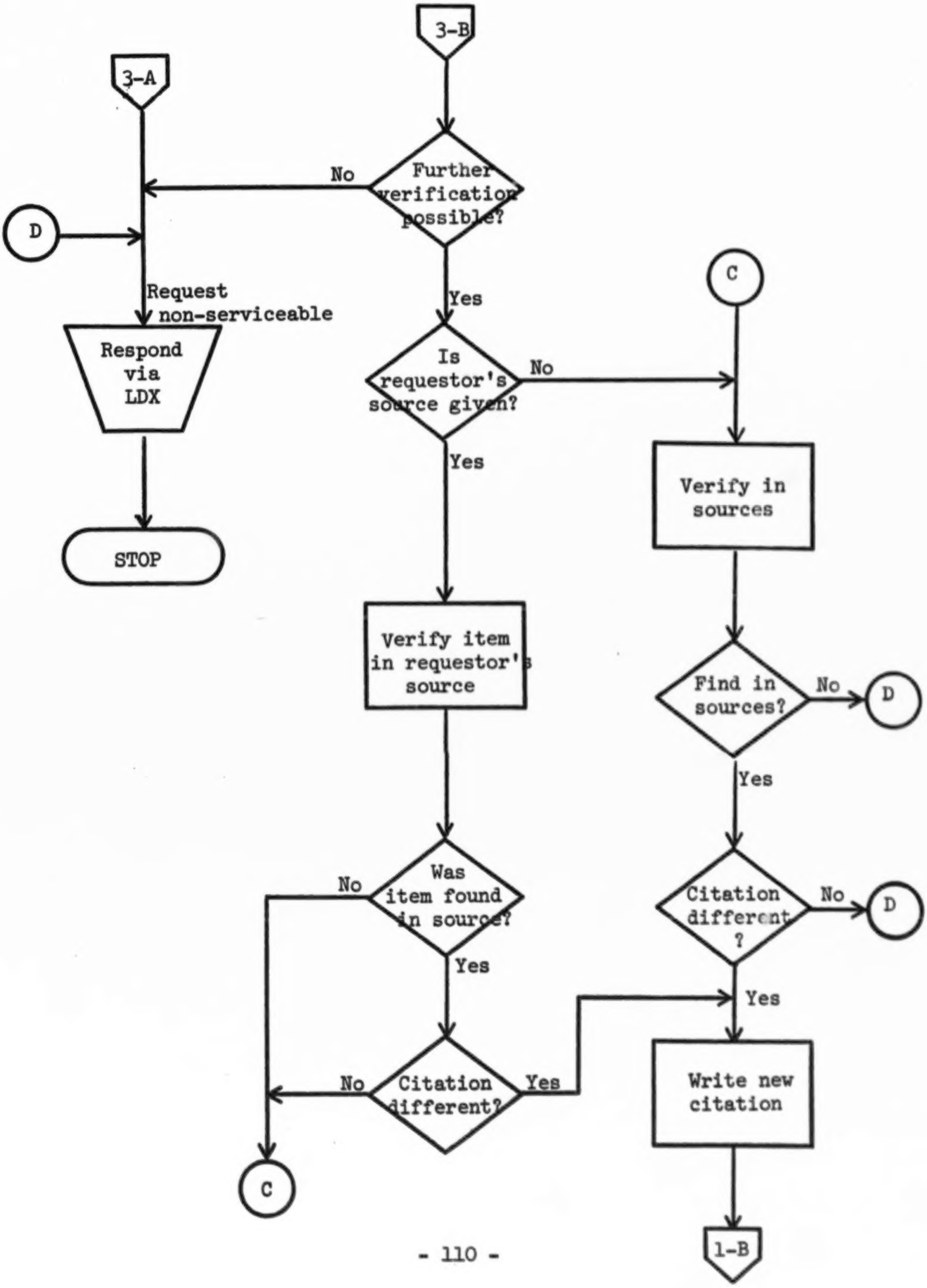
Non-Batch Processing Chart - Berkeley
(Request Receipt to LDX Transmission)


START
From Davis faculty or I.L.L.
Incoming request
Take request information
1-B
Location present?
Yes
No
Catalog look-up
Find in catalog?
Yes
No
3
Verification
1-A
Go to location
Note location(s) and call number(s)
To LDX journal
Look up call number in file
No
Call number?
Yes
Page item
Item on shelf?
No
2
Yes
Charge item to project
Take to LDX
STOP

Non-Batch Processing Chart - Berkeley (Cont.)


2
B
Check charge file
Find in charge file?
No
Yes
Item avail. at other loc. ?
Yes
1-A
No
Avail. here in 24 hours ?
No
3-A
Yes
Place hold & note on transaction card
STOP
Departmental catalog look-up
No
Call number obtained locally?
Yes
Further assistance avail. locally?
No
Yes
Local verification
Can item now be repaged?
Yes
A
No
Item avail.at other loc. ?
No
3-B
Yes
1-A
Different citation obtained from catalog?
No
A
Yes
Repage item
On shelf?
No
B
Yes
Charge item to project
Take to LDX
STOP

Non-Batch Processing Chart - Berkeley (Cont.)


3-B
3-A
Further verification possible?
No
Yes
D
Request non-serviceable
Respond via LDX
STOP
C
Is requestor's source given?
No
Yes
Verify in sources
Verify item in requestor's source
Find in sources?
No
D
Yes
Was item found in source?
No
Yes
Citation different?
No
D
Yes
Citation different?
No
Yes
Write new citation
C
1-B

D. CONTROL SHEET EXAMPLES.

1. Item control sheet.

INSTITUTE OF LIBRARY RESEARCH

LDX PROJECT - ITEM CONTROL SHEET

Transaction number		☐ REA to:	
Date	Batch	☐ Hold placed	
Call number			
Location			

Date	Vol.	No.	Pages

Journal

Author (of article)

Title (of article)

Operation	Time in	Time out
Request receipt		
Catalog look-up	— — —	— — —
Paging	— — —	— — —
Copying (914)		
LDX transmission		
Verification		

Begin phoning		No. of calls
Time reached		

Source of request
☐ ILL ☐ Direct

Request
☐ Serviced ☐ Not serviced

Requestor

Department

Status	Telephone

Tie line
☐ Time
☐ No. tries

Source

☐ Material not sent because:
- ☐ NOS ☐ NICF ☐ DNC
- ☐ Not in CU (verified)
- ☐ Not in sources checked
- ☐ Incomplete info. ________________
- ☐ Other ____________________

☐ Verification done

☐ Main	☐ Local
☐ ULS	☐ REQ
☐ NST/LC	☐ Cat/Libn.
☐ CU Bk Cat.	☐ Other ________
☐ Serials	________________
☐ Other ________	________________

Materials received by:

X ______________________________

Date	Time

2. Batch control sheet.

INSTITUTE OF LIBRARY RESEARCH

LDX PROJECT - BATCH CONTROL SHEET

Instructions: Record clock time for each operation.

Date ________________

Operation		Batch Number and Page								
		1	2	3	4	5	6	7	8	9
Begin processing										
Leave ILR										
Begin look-up										
End look-up										
Arrive 1st loc.										
Leave last loc.										
Arrival at LDX										
Leave LDX										
Begin verification										
End verification										
Return ILR										
Rebatch	X									

The following transactions have been re-batched:

TR#	B_1	B_2	Reason	TR#	B_1	B_2	Reason

3. Transmission control sheet.

INSTITUTE OF LIBRARY RESEARCH

LDX PROJECT - TRANSMISSION CONTROL SHEET

Date____________________

Transaction number	Batch	Copying 914		Transmit LDX		Number of pages	Operator
		Start	Stop	Start	Stop		

E. SOURCES OF VERIFICATION.

Occasionally, if pertinent data are missing or incorrect, it may be necessary to verify a citation. In most instances you will be able to do your verification in the Reference Room of the Main Library. The catalog of Reference Room materials and an abbreviations catalog are located to the right of the reference desk (as you face it). Above the catalog is a map which will help you to locate the material on the Reference Room shelves.

Since inclusive publication dates are noted on the spine of most of the volumes listed below, always note carefully the date of the article you wish to locate.

To determine or verify a journal title when the author and article title are not given, consult the following periodical directories and union lists located in the Reference Room:

1. Directories:

   Ulrich's International Periodical Directory, 1965-date.

      Subject arrangement: see "Key to Subjects" in front of each volume.

      Vol. 1: Scientific, technical and medical.

      Vol. 2: Art, humanities, social science and business.

   Standard Periodical Directory, 1964/65-date.

      Subject arrangement (Reference Desk).

   N.W. Ayer and Son's Directory of Newspapers and Periodicals, 1880-date.

      Geographical arrangement with alphabetical index (Reference Desk).

2. Union lists (arranged in alphabetical order by title unless otherwise noted):

   Union List of Serials in Libraries of the United States and Canada

      For journals which began publication prior to 1950.

   New Serial Titles (NST), 1950-date.

   British Union Catalogue of Periodicals (BUCOP), 1955; supp. to 1960.

      Alphabetical by title.

   British Union Catalogue of New Periodical Titles, 1960-date.

World List of Scientific Periodicals (WLSP).

WLSP New Periodical Titles, 1960-date.

When you know the author, title or subject of an article, a journal citation may be located by means of the various periodical indexes located in the Reference Room and branch libraries. These usually contain a list of the periodicals that they index. This list is generally near the beginning of each volume. Some indexes cover a wider range of subjects; others are limited to special fields. The most frequently used periodical indexes for the humanities and social sciences are shelved in the Periodical Index floor cases in the Reference Room. Most index by author and subject (those marked with an asterisk index only by subject).

3. General indexes in Reference Room:

   Readers' Guide to Periodical Literature, 1900-date.

   Social Sciences and Humanities Index, 1907 (formerly called Readers' Guide to Periodical Literature Supplement, 1907-1919, and International Index, 1920-March, 1965).

   *Poole's Index to Periodical Literature, 1802-1907.

   Nineteenth Century Readers' Guide to Periodical Literature, 1890-1899; 1900-1922.

   *Cumulated Magazine Subject Index, 1907-1949.

4. Specialized periodical indexes in Reference Room:

   *Public Affairs Information Service (PAIS), 1915-date.

   Indexes magazine articles, documents, pamphlets and books in the fields of sociology, economics and political science.

   *Business Periodicals Index, 1958-date.

   *Applied Science and Technology Index, 1958-date.

   Industrial Arts Index, 1913-1916; 1918-1957.

   Art Index, 1929-date.

   Education Index, 1929-date.

   Psychological Abstracts, 1927-date.

   Also in Biology, Ed.-Psych. libraries.

   British Humanities Index, 1915 (formerly Subject Index to Periodicals, 1915-1962).

5. Other specialized magazine indexes which you may need to use are located in branch libraries as shown below:

Biology

Agricultural and Biology Indexes

Biology Abstracts

Chemical Abstracts (also in Chemistry, Physics, Engineering, Bio-Chemistry and Public Health Libraries).

Engineering

Engineering Index

Physics Abstracts

Law

Index to Legal Periodicals

Library Science

Library Literature

Mathematics

Mathematical Reveiws

Music

Music Index

General hints: Periodicals are listed by title in the library catalogs except for journals or bulletins of a society which are listed under the name of the society, e.g.:

American Chemical Society
The journal. . .

Location of journals: Usually, periodicals more than a year old are bound into volumes, given call numbers just as books are, and shelved with books in the Loan stacks or in branch libraries. (If the card in the Author-Title Catalog gives a call number without designating a location, the journal is in the Main Library.)

Go to the Periodical Desk for current, unbound issues. The Author-Title Catalog may refer you to the Periodical Desk for "holdings"--the list of issues in the Library--even though the periodical may be shelved in another location. The Lindex in the Reference Room gives the location of several thousand indexed periodicals.

APPENDIX II: MISCELLANEOUS INFORMATION

A. FILE ORGANIZATION AND LIST OF ANALYTICAL PROGRAMS.

The LDX tape file was generated from a SNOBOL program, which accepted punched card input. All data on the tape are in BCD mode. The file consists of 534 logical records, (one logical record per transaction) of which the first 482 were handled by LDX. The remaining 52 were not handled by LDX due to machine difficulty.

Each logical record consists of 7 physical records, of which the first 6 contain 72 characters of data and the seventh, 40 characters. Each logical record includes most of the data from the item control sheet. In addition, the record also contains the processing, service and waiting intervals which were calculated by the SNOBOL file generation program. The logical record format is presented on the following pages.

RECORD FORMAT ON LDX TAPE

Field number	Item	Tape columns	Number of characters	Physical record
1	Transaction number	1-4	4	1
2	Source	6	1	1
3	Serviced/not serviced	8	1	1
4	Request receipt date	10-11	2	1
5	Time in	13-16	4	1
6	Time out	18-21	4	1
7	Interval	23-27	5	1
8	Look-up code	29	1	1
9	Batch	31-32	2	1
10	Date	34-35	2	1
11	Time in	37-40	4	1
12	Time out	42-45	4	1
13	Interval	47-51	5	1
14	Paging code	53	1	1
15	Batch	55-56	2	1
16	Date	58-59	2	1
17	Time in	61-64	4	1
18	Time out	66-69	4	1
19	Interval	71-72; 1-3	5	1/2
20	Copying code	5	1	2
21	Date	7-8	2	2
22	Time in	10-13	4	2
23	Time out	15-18	4	2
24	Interval	20-24	5	2
25	Transmission code	26	1	2
26	Date	28-29	2	2
27	Time in	31-34	4	2
28	Time out	36-39	4	2
29	Interval	41-45	5	2
30	Verification code	47	1	2
31	Date	49-50	2	2
32	Time in	52-55	4	2
33	Time out	57-60	4	2
34	Interval	62-66	5	2
35	Davis processing date	68-69	2	2
36	Time in	71-72; 1-2	4	2/3
37	Time out	4-7	4	3
38	Number of calls	9	1	3
39	Pickup date	11-12	2	3
40	Pickup time	14-17	4	3
41	Interval	19-23	5	3
42	Number of pages	25-27	3	3
43	Multiple pages	29	1	3
44	Non-standard handling	31	1	3

RECORD FORMAT ON LDX TAPE (Cont.)

Field number	Item	Tape columns	Number of characters	Physical record
45	Reason N.S.	33	1	3
46	V-sources	35-36	2	3
47	Copy acceptable	38	1	3
48	Material used	40	1	3
49	Mattered	42	1	3
50	Willingness to pay	44	1	3
51	Amount	46	1	3
52	Research grant	48	1	3
53	Comments	50	1	3
54	Identical number	52-55	4	3
55	Extended processing	57	1	3
56	Title	59-72; 1-57	71	3/4
57	Name	59-72; 1-11	25	4/5
58	Department	13-14	2	5
59	Page begin	16-19	4	5
60	Page end	21-24	4	5
61	Call number	26-41	16	5
62	Location	43-44	2	5
63	Publication date	46-49	4	5
64	Volume	51-53	3	5
65	Type Ext 1	55	1	5
66	Code	57	1	5
67	Batch	59-60	2	5
68	Date	62-63	2	5
69	Time in	65-68	4	5
70	Time out	70-72; 1	4	5/6
71	Interval	3-7	5	6
72	Type Ext 2	9	1	6
73	Code	11	1	6
74	Batch	13-14	2	6
75	Date	16-17	2	6
76	Time in	19-22	4	6
77	Time out	24-27	4	6
78	Interval	29-33	5	6
79	Receipt to transmission (9-Hr.)	35-39	5	6
80	Receipt to notification (9-Hr.)	41-45	5	6
81	Receipt to pickup (9-Hr.)	47-51	5	6
82	Receipt to transmission (24-Hr.)	53-58	6	6
83	Receipt to notification (24-Hr.)	60-65	6	6
84	Receipt to pickup (24-Hr.)	67-72	6	6
85	Size of batch	1-2	2	7
86	Number of locations	4	1	7

RECORD FORMAT ON LDX TAPE (Cont.)

Field number	Item	Tape columns	Number of characters	Physical record
87	Processing wait interval	6-10	5	7
88	Copying wait	12-16	5	7
89	Transmission wait	18-22	5	7
90	Notification wait	24-28	5	7
91	Wait to first notification	30-34	5	7
92	Pick-up wait	36-40	5	7

LDX PROGRAM ANALYSIS

PROGRAM	LANGUAGE	INPUT FROM	OUTPUT TO	OUTPUT CONTENT
I. File Maintenance				
A. Master file	SNOBOL		Master tape	
1. Edit & master file generation		Cards		Coded and edited data by transaction.
2. Update of master file		Master tape & cards		Updated transaction data.
3. Generation of 7th record on master file		Master tape & cards		Batch data, added to transaction data.
B. Abstractions from master file	SNOBOL	Master tape	Punched cards	
1. Requestors & responses				Transaction number, requestor dept., questionnaire responses.
2. Titles & publication dates				Transaction number, title, publication date, source.
3. Batch data				Batch numbers, request receipt date, R-T-9, etc.
II. Transaction Analysis				
A. Frequency counts	STATPAK	Master tape	Printer	Frequency count
1. Items looked up, paged, copied, transmitted, verified and requiring extended processing				All, S/NS

LDX PROGRAM ANALYSIS (Cont.)

PROGRAM	LANGUAGE	INPUT FROM	OUTPUT TO	OUTPUT CONTENT
2. Transactions: ILL/DIR, S/NS, ILL & S/ILL & NS, DIR & S/DIR & NS, 1st week, 2nd week, 3rd week, 4th week				
B. Frequency distributions	STATPAK	Master tape	Printer	Plot, means, standard deviation, frequency count
1. Request receipt date				All, ILL/DIR
2. Request receipt hour				All, ILL/DIR
3. Publication date				1870-1970; 1920-1967 (discrete)
4. Why requests not serviced				All, ILL/DIR
5. Davis requestors' departments				All
6. Library locations of journals at Berkeley				All
7. LDX pages transmitted				All
8. Book pages transmitted				All
9. Multiple book pages per LDX page				All
10. Questionnaire responses				S, ILL & S, ILL & DIR
11. Phone calls				All
12. Intervals				

LDX PROGRAM ANALYSIS (Cont.)

PROGRAM	LANGUAGE	INPUT FROM	OUTPUT TO	OUTPUT CONTENT
a. Internal processing				All, DIR, S/NS, ILL, S/NS, S, NS, by weeks.
b. Extended processing				Items requiring extended processing.
c. Service intervals				All, DIR, S/NS, ILL, S/NS, S, NS, by weeks.
d. Wait intervals				All, NS, S, by week.
C. Correlations	STATPAK	Master tape	Printer	Means, standard deviation, correlations.
1. Questionnaire responses with publication date				S
2. Receipt to notification interval with processing wait interval				S
III. Batch Analysis				
A. Calculation of batch intervals	SNOBOL	Cards	Punched cards	Paging date, batch number, time in & out of process cycle. Number in batch, number of locations in batch, process interval.
B. Frequency distributions	STATPAK	Cards	Printer	Plots, means, standard deviation.
1. Batch size				
2. Locations				
3. Process cycle interval				
C. Correlations	STATPAK	Cards	Printer	Means, standard deviation, correlation.
1. Size with number of locations, with processing cycle interval				

LDX PROGRAM ANALYSIS (Cont.)

PROGRAM	LANGUAGE	INPUT FROM	OUTPUT TO	OUTPUT CONTENT
D. Regression	STATPAK	Cards	Printer	Coefficients, standard error of coefficients, etc.
1. Process cycle interval, with batch size, with number of locations				
IV. System Analysis				
A. Cost analysis	FORTRAN	Cards	Printer	System cost

KEY

All	All items
S	Serviced
NS	Not serviced
ILL	Interlibrary Loan request
DIR	Direct request

B. MATERIAL TO FACULTY.

UNIVERSITY OF CALIFORNIA, BERKELEY

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SANTA BARBARA • SANTA CRUZ

INSTITUTE OF LIBRARY RESEARCH
BERKELEY, CALIFORNIA 94720

February 28, 1967

Dear Sir:

During the month of March, the Institute of Library Research (ILR) is conducting an experiment in facsimile transmission from the Berkeley campus to the Davis campus utilizing Xerox Long Distance Xerography (LDX) equipment. During the experiment, you may phone ILR and request journal articles which you would normally obtain through interlibrary loan. The ILR telephone number and the information you will be asked to supply are listed on the attached sheet. If available, copies of the articles you request will be sent via LDX.

If you are able to give us the call number of the journal which contains the article you want, it will expedite the handling of your requests; however, we are prepared to handle requests which do not have a call number. A printed catalog of the Berkeley libraries, produced in 1963, is available in the Bibliographic Center, which is located on the first floor of the General Library. If a journal began publication prior to 1963, the catalog will usually tell you if it is available on the Berkeley campus.

The Davis Interlibrary Loan Office (second floor, Library) is prepared to assist in preparing LDX requests. If you prefer, they will place your requests for journal articles available on the Berkeley campus. Requests placed in this way will also be sent via LDX.

During the experiment, you may have difficulty getting the Davis - Berkeley tie line. To determine the extent of this difficulty, please keep track of the time you spend getting the tie line. During working hours, tie line traffic is lightest from 8:00 to 9:00 a.m., and from 12 noon to 1:30 p.m.

We expect that materials handled through this system will be available in the Davis Library between two and four hours from the time you place your request, provided that it does not require special attention. You will be notified by phone when your material has been received at Davis. Materials will be available at the Reference Desk (second floor, Library) within 15 minutes after notification. If your request cannot be serviced, we will notify you or your department secretary and transfer the request to the Davis Interlibrary Loan Office for further processing.

If you have used the LDX service, you will receive, via regular campus mail, a brief questionnaire which requests information that will assist us in evaluating the effectiveness of the LDX system. Your cooperation in this experiment is genuinely appreciated. We will be happy to answer questions which arise during the course of the experiment.

Sincerely,

Jerry Newton
Gerald D. Newton
Technical Coordinator (Davis)

William D. Schieber
William D. Schieber
Technical Coordinator (Berkeley)

WDS:fb
Encl.

UNIVERSITY OF CALIFORNIA
INSTITUTE OF LIBRARY RESEARCH

LDX PROJECT
PROCEDURES OF PLACING TELEPHONE REQUESTS

Institute of Library Research (ILR) Telephone Number: 128 + 23 + 1228

Please supply the following information when making a telephone request for a journal article (when making a request, first tell the person who answers that you are making a request):

A. Item identification:

   (1) call number
   (2) journal title
   (3) author of article
   (4) article title
   (5) journal date and/or volume and issue number
   (6) inclusive pages of article

B. Source of citation to requested article (please include page and, if periodical, date).

C. Identification of requestor:

   (1) first and last name
   (2) department
   (3) telephone number where you wish to be notified when request has been serviced.

If any questions arise in connection with your use of the LDX facilities, you may contact the Interlibrary Loan Office (ext. 2-1128), Gerald Newton (ext. 2-1626) or William Schieber (Berkeley, 128 + 23 + 1228).

C. TIMING OF THE EXPERIMENT.

TIMING

Item	Operation	Interval
A.	PRELIMINARY PLANNING	to Jan. 8
1	Meetings with key people	week of Dec. 19
2	ILR Review of plans	week of Dec. 26
3	Preliminary flow charting	week of Jan. 2
B.	GENERAL DESIGN	Jan. 9 - Feb. 28
1	Flow chart new procedures	week of Jan. 9
2	Review new procedures	week of Jan. 16
3	Prepare data collection forms	Jan. 9 - Jan. 30
4	Set up manual of procedures	Jan. 23 - Feb. 6
5	Review of manual	Feb. 6 - Feb. 27
6	Personnel hiring	Jan. 30 - Feb. 13
7	Personnel training (with Xerox)	Feb. 13 - Feb. 28
8	Transmission line testing (Pac. Tel.)	week of Feb. 20
9	Equipment inst. & testing (Xerox)	Feb. 27 - Feb. 28
10	Publicity (preparation and dist.)	Feb. 13 - Feb. 27
C.	LDX RUN and Monitoring of experiment	month of March
D.	DATA ANALYSIS	month of April
1	Keypunching	
2	Computer analysis	
3	Derivative charts, tables, etc.	
E.	PROJECT REVIEW AND REPORT WRITING	May - December
	Draft report	August
	Final report publication	February, 1968

D. LDX EQUIPMENT SPECIFICATIONS

1. Scanner.

   a. Input pages:

      Up to 9-1/2 inches wide by any length.

      3-1/4 inches by 5 inches minimum size.

      Accepts limited variations in image, color, and background.

   b. Operator signals:

      "Ready" light indicates system is ready to transmit; also flashes intermittently during transmission of negative originals.

      "Standby" light illuminates during warm-up period; to indicate transmission failure; or when printer is not ready to receive.

   c. Feed system:

      Manual conveyor feed. Accepts creased, torn and dog-eared sheets.

   d. Scanning:

      Cathode ray tube line-scan with photomultiplier pickup, 8-1/4 inches wide.

   e. Power:

      115 volts, single phase AC (conventional grounded circuit).

   f. Environment:

      Temperature: 50° to 100°F.

      Relative humidity: 15% to 85%.

      Elevation: 0 to 5500 feet above sea level.

   g. Size:

      46 inches high.

      24 inches wide.

      46 inches deep.

      Floor area: 7.6 square feet.

      Weight: 425 pounds.

2. Printer.

   a. Output pages:

      8-1/2 inches wide by any length.

      Prints on ordinary paper from 2,000 feet roll; also can print on paper offset master stock in roll form.

      Automatic cutter trims documents to length.

   b. Operator signals:

Reload light indicates low paper supply.

"Standby" light indicates warm-up period in progress; also indicates transmission failure.

"Ready" light indicates the Printer is properly connected to the Scanner and is ready to receive and print.

c. Printing:

Cathode ray tube, optics, xerographic drum and electronic circuits.

d. Power:

115 volts, singe phase AC (conventional grounded circuit).

e. Environment:

Temperature: 60° to 90°F.

Relative humidity: 15% to 85%.

Elevation: 0 to 5500 feet above sea level.

f. Size:

58.9 inches high.

25.6 inches wide.

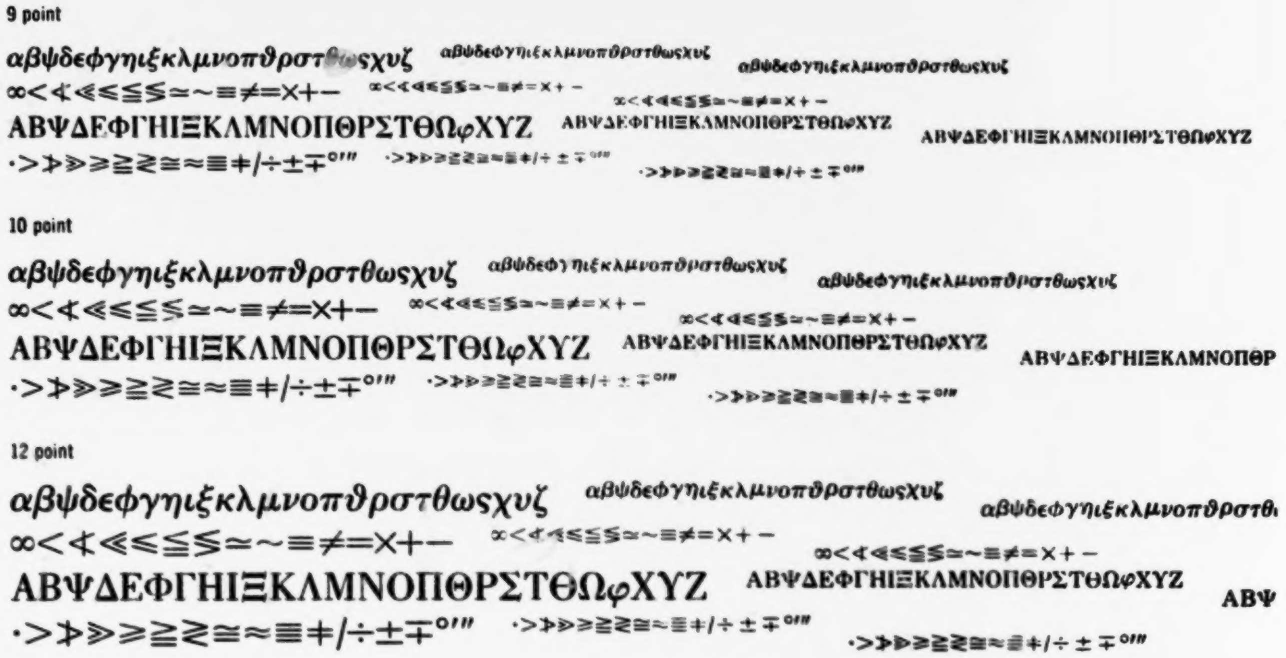
33 inches deep.

Floor area: 5.9 square feet.

Weight: 650 pounds.

APPENDIX III: SAMPLES OF LDX COPIES AND ORIGINAL MATERIALS

On the following pages we have included samples of Xerox LDX copies which were made during the experiment. The sample material consisted of several test patterns and type fonts which were copied on the LDX scanner (at a resolution of 135 lines per inch) and printed at the receiving station. Each page contains one set: the original copy occupies the top half of the page, and the LDX copy of that original is found on the lower half.



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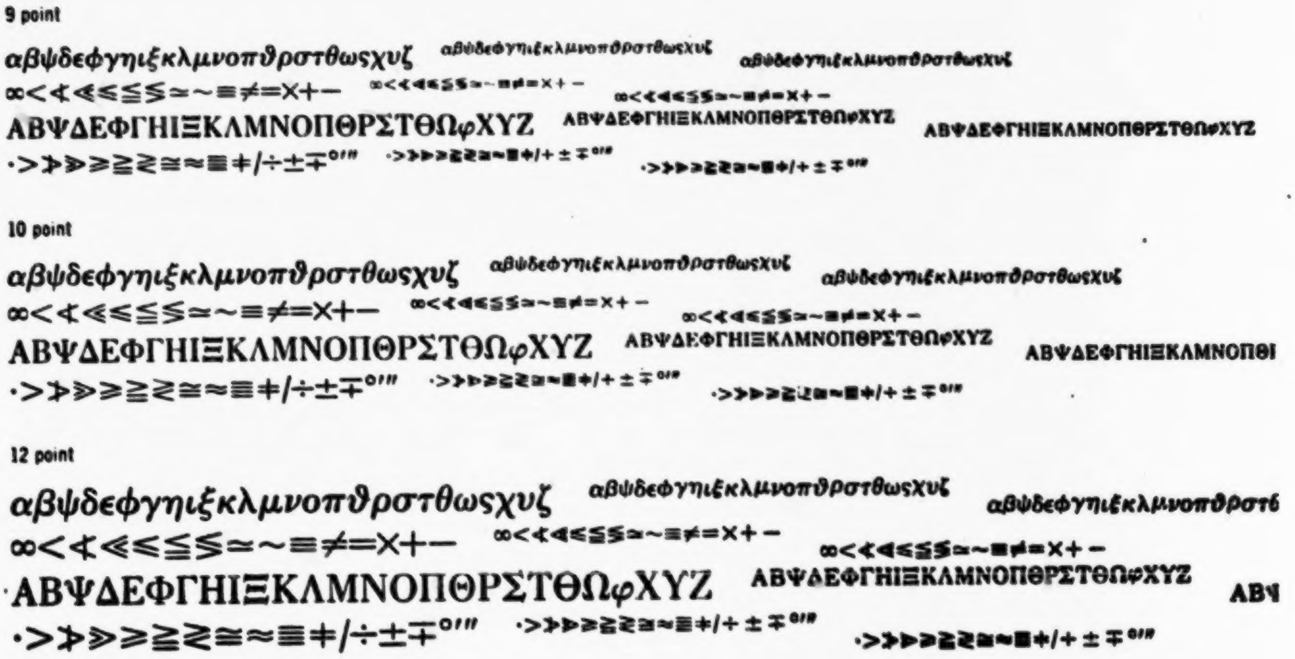
Original Copy



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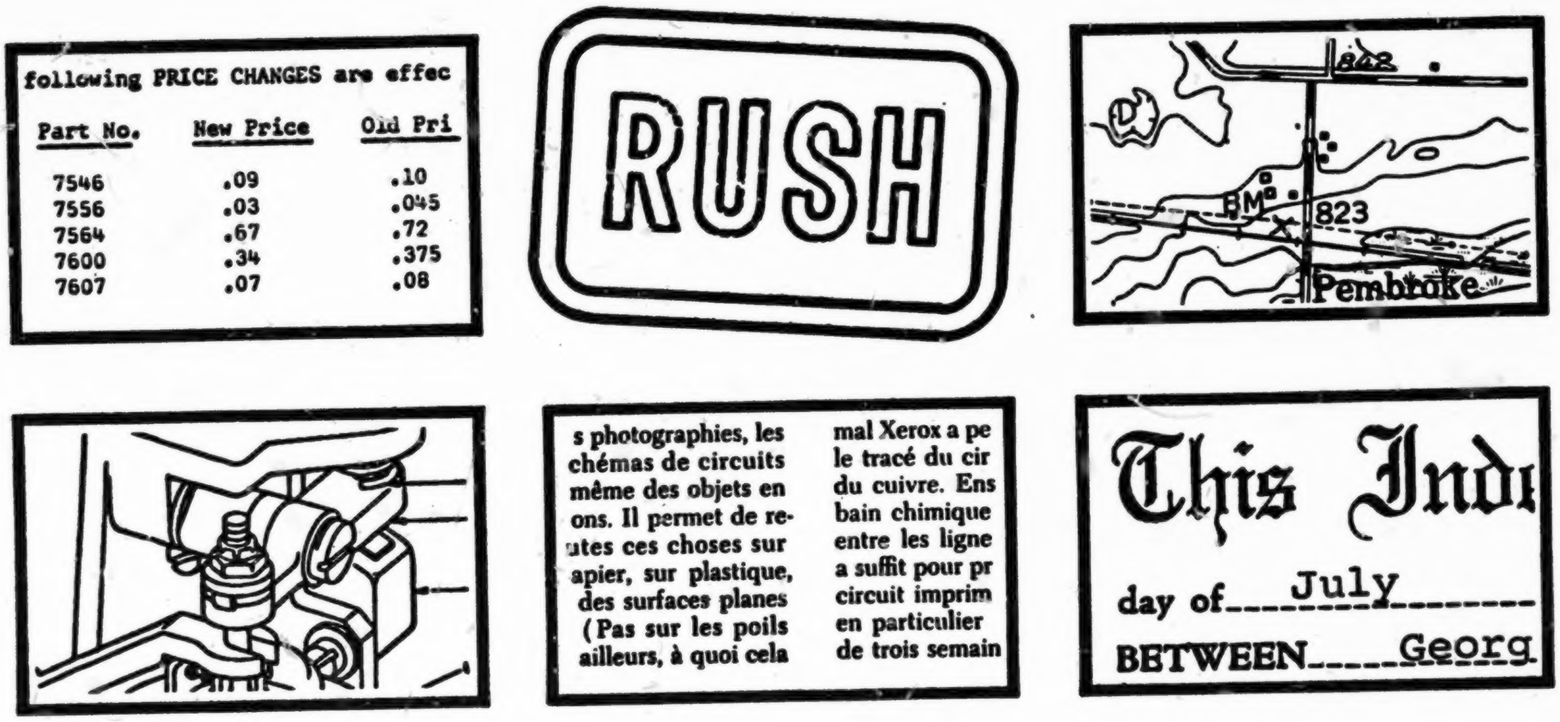

following PRICE CHANGES are effec

Part No.	New Price	Old Pri
7546	.09	.10
7556	.03	.045
7564	.67	.72
7600	.34	.375
7607	.07	.08

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même des objets en
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des surfaces planes
(Pas sur les poils
ailleurs, à quoi cela

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a suffit pour pr
circuit imprim
en particulier
de trois semain

This Indi

day of____July_______

BETWEEN_____Georg

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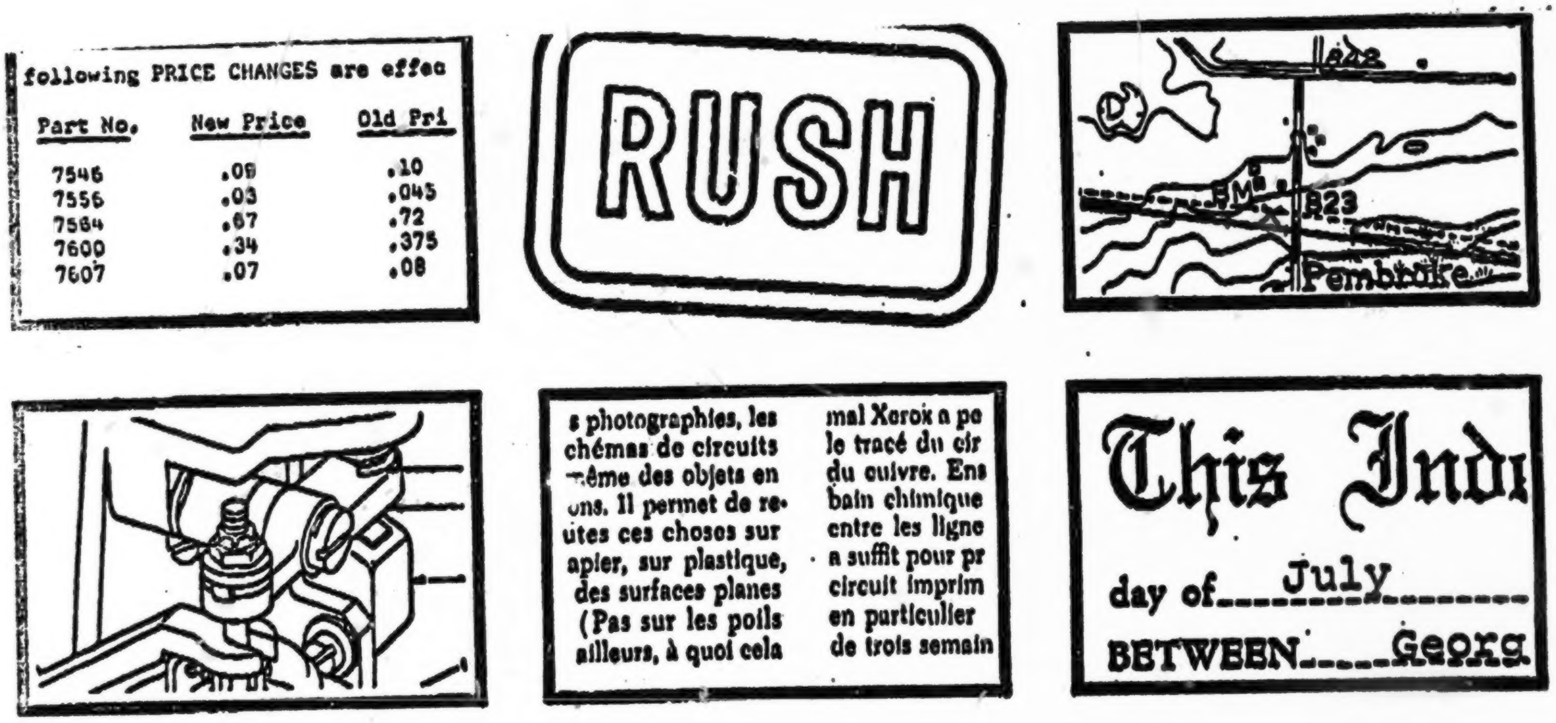

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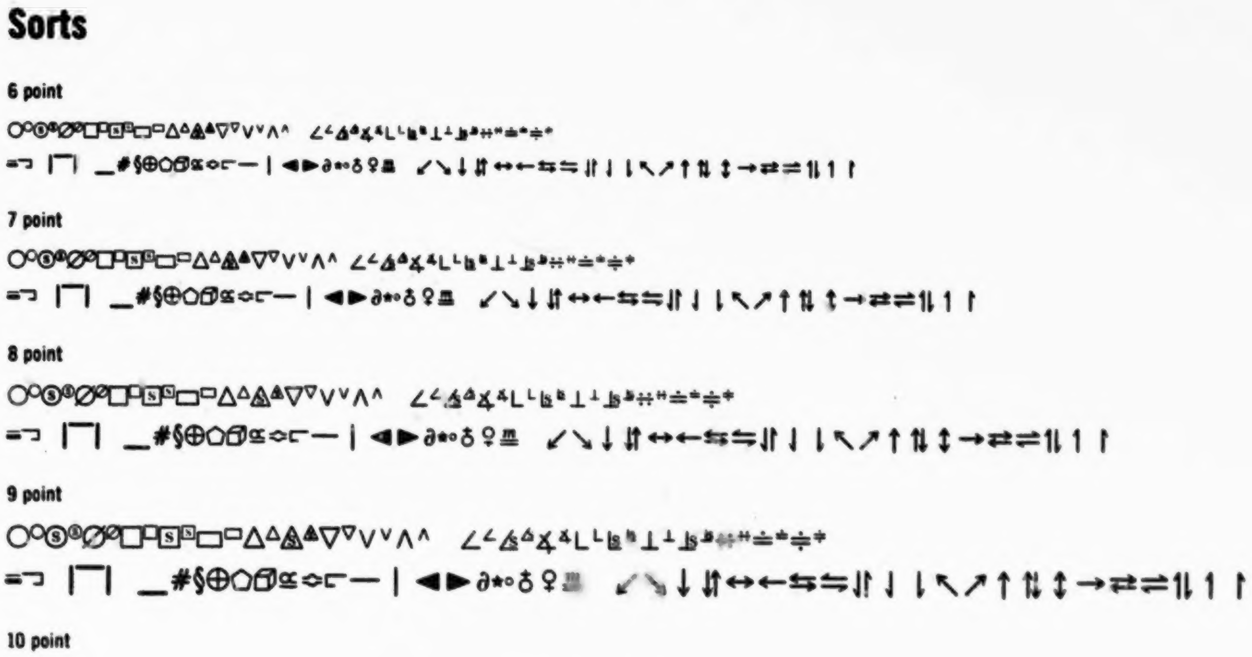

Sorts

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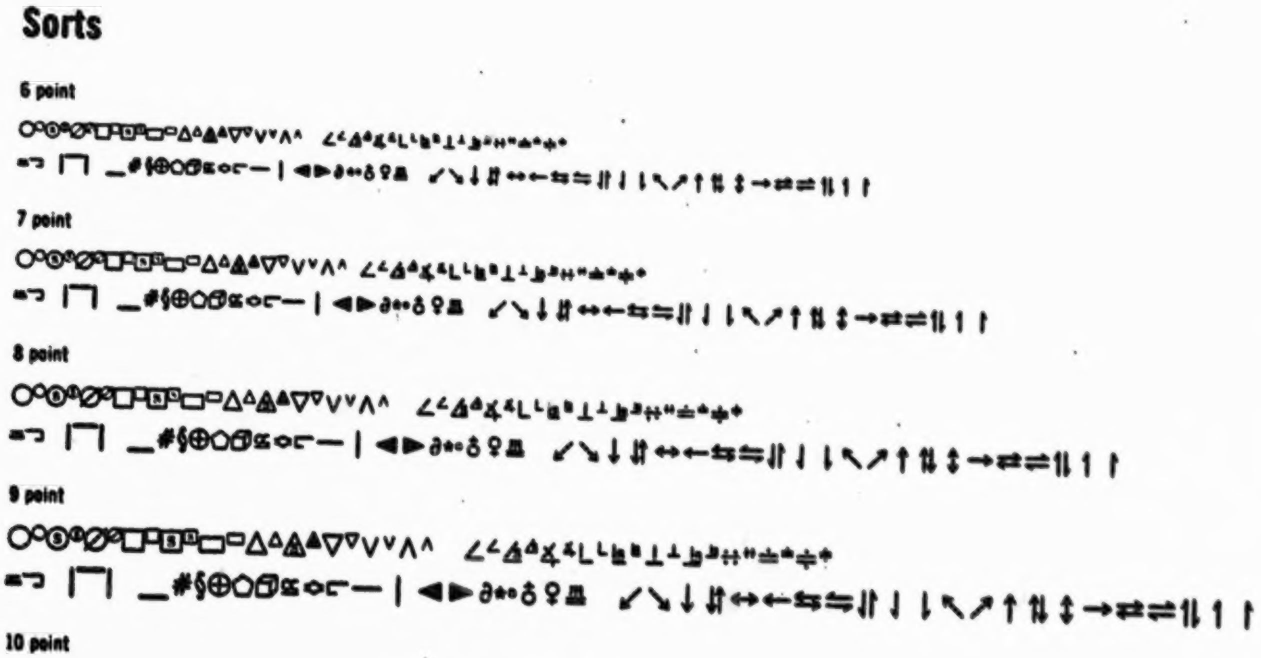

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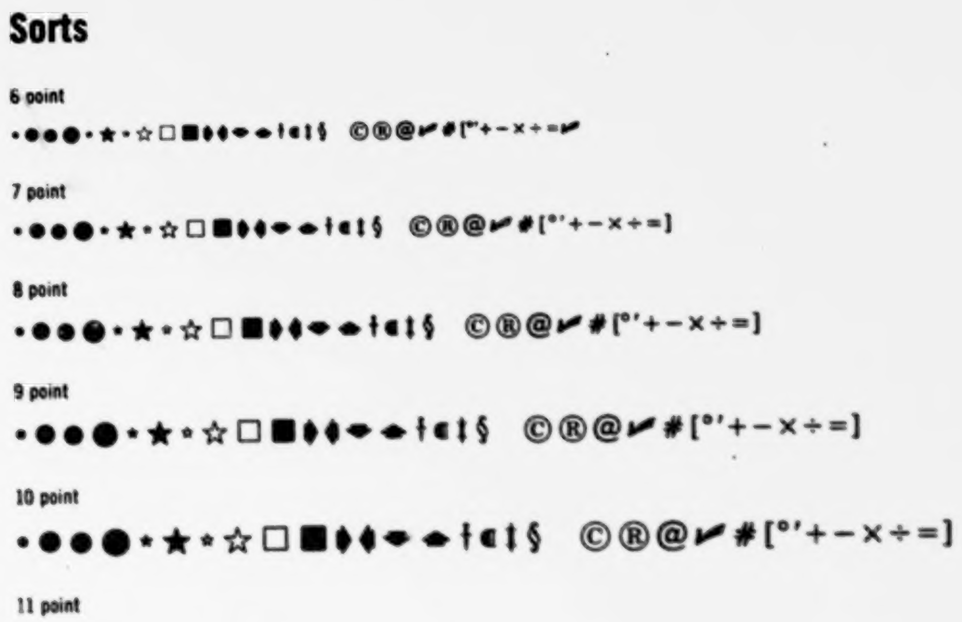

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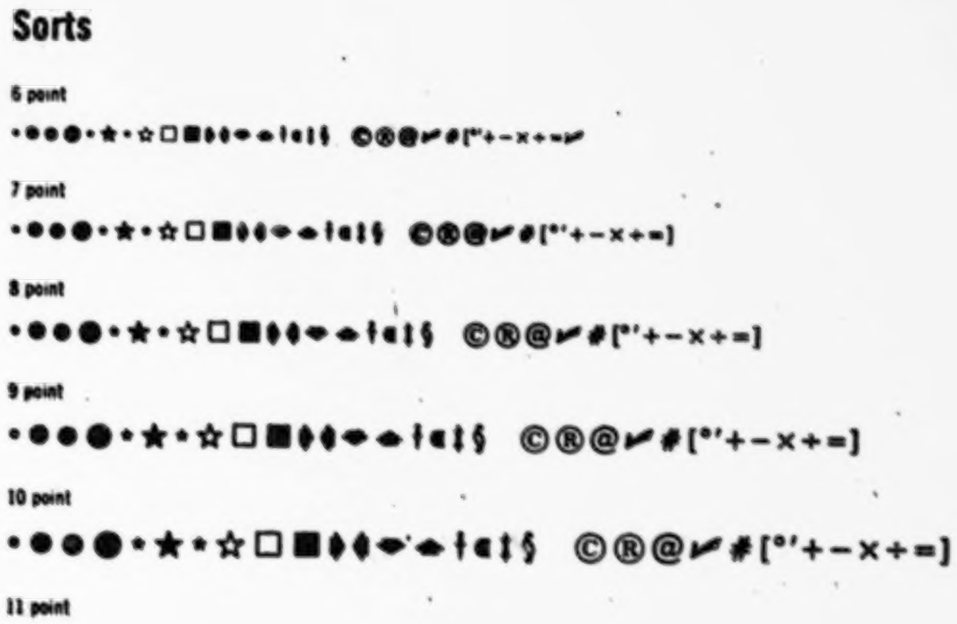

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175	2.	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
180	1.95	20	23	27	31	35	39	43	47	51	55	59	62	66	70	74	78	82
185	1.9	19	23	27	30	34	38	42	46	49	53	57	61	65	68	72	76	80
190	1.85	19	22	26	30	33	37	41	44	48	52	56	59	63	67	70	74	78
195	1.8	18	22	25	29	32	36	40	43	47	50	54	58	61	65	68	72	76
200	1.75	18	21	25	28	32	35	39	42	46	49	53	56	60	63	67	70	74
206	1.7	17	20	24	27	31	34	37	41	44	48	51	54	58	61	65	68	71
212	1.65	17	20	23	26	30	33	36	40	43	46	50	53	56	59	63	66	69
218	1.6	16	19	22	26	29	32	35	38	42	45	48	51	54	58	61	64	67
225	1.55	16	19	22	25	28	31	34	37	40	43	47	50	53	56	59	62	65
233	1.5	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
241	1.45	15	17	20	23	26	29	32	35	38	41	44	46	49	52	55	58	61
250	1.4	14	17	20	22	25	28	31	34	36	39	42	45	48	50	53	56	59
260	1.35	14	16	19	22	24	27	30	32	35	38	41	43	46	49	51	54	57
270	1.3	13	16	18	21	23	26	29	31	34	36	39	42	44	47	49	52	55
Alphabet Length	1	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42

Original Copy

170	2.05	21	25	29	33	37	41	45	49	53	57	62	66	70	74	78	82	86
175	2.	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80	84
180	1.95	20	23	27	31	35	39	43	47	51	55	59	62	66	70	74	78	82
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190	1.85	19	22	26	30	33	37	41	44	48	52	56	59	63	67	70	74	78
195	1.8	18	22	25	29	32	36	40	43	47	50	54	58	61	65	68	72	76
200	1.75	18	21	25	28	32	35	39	42	46	49	53	56	60	63	67	70	74
206	1.7	17	20	24	27	31	34	37	41	44	48	51	54	58	61	65	68	71
212	1.65	17	20	23	26	30	33	36	40	43	46	50	53	56	59	63	66	69
218	1.6	16	19	22	26	29	32	35	38	42	45	48	51	54	58	61	64	67
225	1.55	16	19	22	25	28	31	34	37	40	43	47	50	53	56	59	62	65
233	1.5	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63
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270	1.3	13	16	18	21	23	26	29	31	34	36	39	42	44	47	49	52	55
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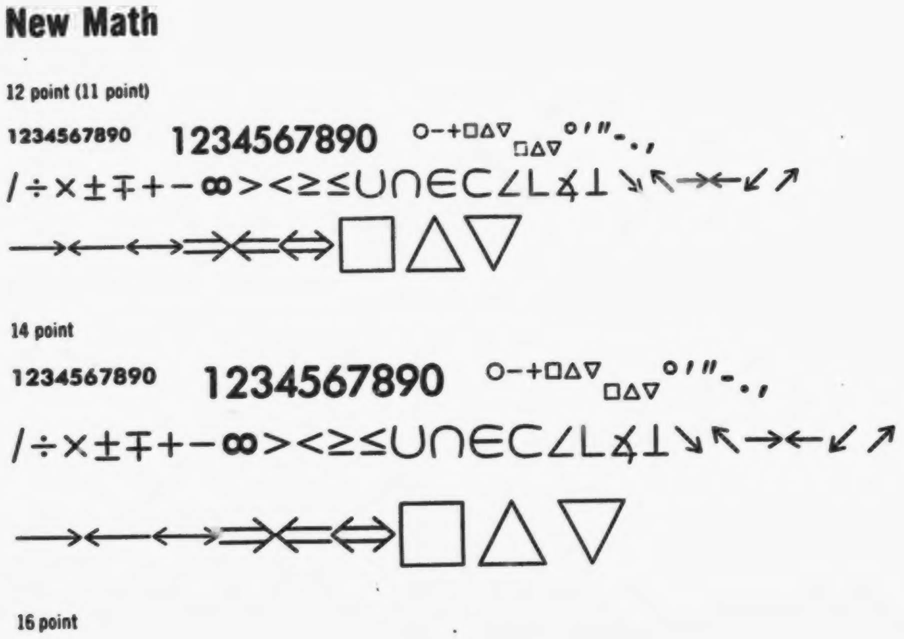

New Math

12 point (11 point)

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16 point

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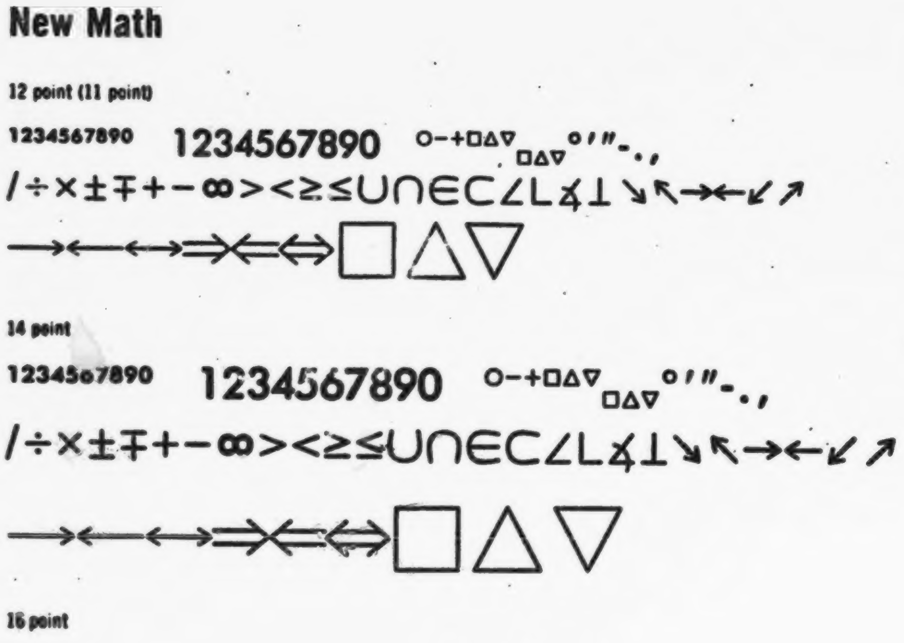

New Math

12 point (11 point)

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